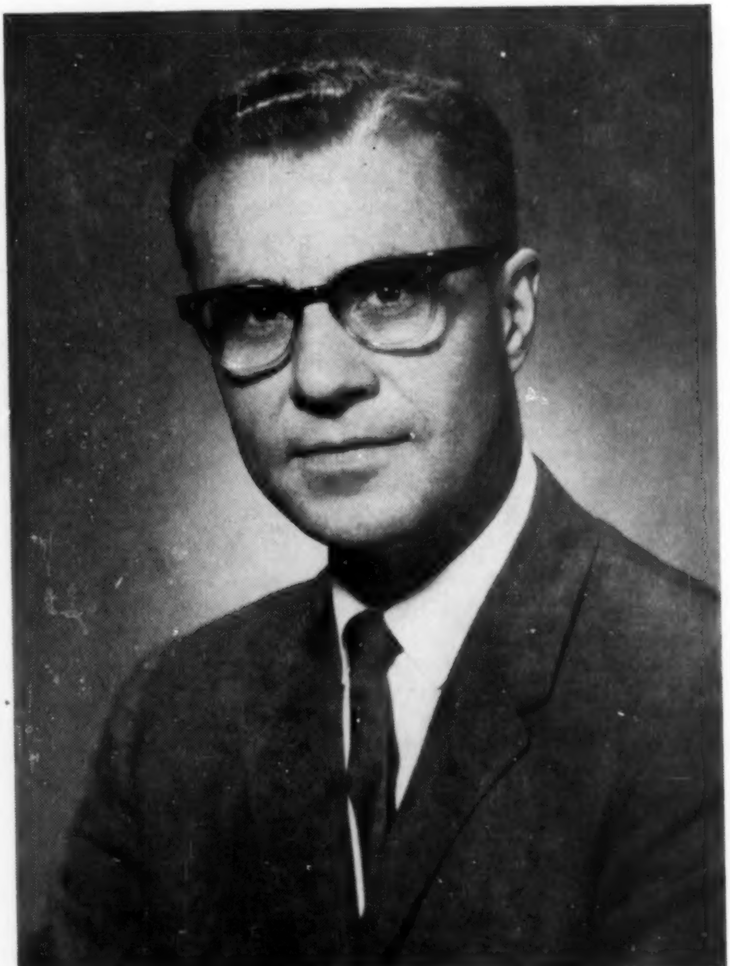
SCIENCE EDUCATION



CLARENCE HARRY BOECK

VOLUME 45 MARCH, 1961 NUMBER 2

SCIENCE EDUCATION

THE OFFICIAL ORGAN OF

National Association for Research in Science Teaching
Council for Elementary Science International
Association on the Education of Teachers in Science

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CLARENCE HARRY BOECK

PROFESSOR Clarence Harry Boeck, twenty-eighth president of the National Association for Research in Science Teaching, presided at the Thirty-Fourth Annual meeting of the Association held at Chicago, February 22–25, 1961. His tenure as president continued the aggressive and competent leadership that has characterized presidents of the National Association for Research in Science Teaching during the administrations of the past eight presidents or so.

Clarence Harry Boeck was born in Glenwood, Minnesota, September 27, 1913. His father, Bruno G. Boeck is deceased and his mother Mathilda Johnson Boeck resides in Buffalo Lake, Minnesota. Two younger sisters, Mrs. Erwin Koebnick and Mrs. Ernest Schafer reside in Buffalo Lake. Each at one time taught in the rural schools of Minnesota.

Dr. Boeck attended elementary schools and high school in Buffalo Lake, graduating from the Buffalo Lake High School in 1931. He received three degrees from the University of Minnesota: a B.S. degree in natural science in 1935, a M.A. degree in 1940, and a Ph.D. degree in 1950. The title of his doctoral thesis is "The Inductive Compared to the Deductive Approach to Teaching Secondary School Chemistry."

Dr. Boeck married Grace M. Boothroyd, daughter of Mr. and Mrs. Ralph H. Boothroyd, at Moorhead, Minnesota, August 20, 1939. They have a daughter Marjorie Ann, age 15, who was born in Stillwater, Oklahoma. She is a sophomore in the Southwest High School in Minneapolis. The Boecks are members of the Lake Harriet Methodist Church in Minneapolis. They reside at 5101 Ewing Avenue South, Minneapolis.

During World War II Dr. Boeck served in the U. S. Navy from April 1944 to December 1945 as Electronics Technician, 3rd Class, U.S.S. Winston AKA95, Pacific Theater Operations.

Teaching experience includes:

Harmony Minnesota High School, 1935–1938. All secondary science.

Central High School, Red Wing Minnesota, 1938–1941. Physics and Biology.

Oklahoma State University, Stillwater, Oklahoma, 1941–1947. Instructor Chemistry. During this period, time was taken out for military service and a year of teaching college physics to a College Training Detachment of the Army Air Force on campus.

University of Minnesota, Instructor, University High School, 1948–1950. Physics and Chemistry.

University of Minnesota College of Education Assistant Professor, Head, Science Department, University High School, 1950–1953. Associate Professor, Head, Science Department, University High School, 1953–1960.

Professor, Head Science Department, University High School, 1960.

The list of Dr. Boeck's publications are as follows:

"Tabular Summary of Research on Laboratory Methods of Teaching Natural Science," *Proceedings Oklahoma Academy of Science*, 24:113–114, 1944.

"A Practical Examination in Skills and Techniques Acquired in Freshman Chemistry," *Science Education*, 31:330–34, December, 1947.

"The Inductive Compared with the Deductive Approach to Teaching Secondary School Chemistry," *Proceedings Minnesota Academy of Science*, 19:57–58, 1951.

"Achievement Examination in Secondary School Subjects—Chemistry Form A," Minneapolis: Educational Test Bureau, 1951, 4 p.

Achievement Examination in Secondary School Subjects—Physics Form A," Minneapolis: Educational Test Bureau, 1951, 4 p.

"The Inductive-Deductive Compared to the Deductive-Descriptive Approach to Labora-

tory Instruction in High School Chemistry," *Journal of Experimental Education,* 19:147–53, March, 1951.

"Achievement Examination in Secondary School Subjects—Physics Form B," Minneapolis: Educational Test Bureau, 1952, 4 p.

"The Water Supply in Our Community: A Unit in Chemistry," pp. 44–51 in Emma Birkmaier, ed., Modern School Practices Series; *Illustrative Learning Experiences: University High School in Action,* Minneapolis: University of Minnesota Press, 1952. "Try the Inductive Approach," *Science Education,* 37:81–84, March, 1953.

"Teaching Chemistry for Scientific Method and Attitude Development," *Science Education,* 37:81-84, March, 1953.

"Review of Recent Research in Teaching of Science at Secondary School Level II," *Science Education,* 39:344–56, December, 1955.

"What Research in Science Education is Needed to Strengthen the Secondary School Science Program," *Science Education,* 40:372–74, December, 1956.

"Subjects and Services—Science" pp. 181–89 in Robert Beck, ed., *The 3R's Plus,* Minneapolis, University of Minnesota Press, 1956.

"Suggestions for the Study of Your Program in Science" (with Carl Goossen), *Minnesota Journal of Education,* 36:18–20, May, 1956.

"Fourth Annual Review of Research in Science Teaching" (with Mallinson, Hubler, Reiner, Weaver), *Science Education,* 40:337-357, December, 1956.

"The Relative Efficiency of Reading and Demonstration Methods of Instruction in Developing Scientific Understandings," *Science Education,* 40:92–98, March, 1956.

"The Effects of Capacitance and Frequency on Capacitor Reactance: A Demonstration," *Minnesota Journal of Science.* 1:15–16, October, 1957.

"An Examination of Scientific Method and Attitude," *Science Education,* 41:92–99, March, 1957.

"An Orientation Exercise in Chemistry" (with Roman Carr), *Science Teacher,* 25:411–413, November, 1958.

"The Laboratory Approach to Science Education," *Education,* 80:21–23, September, 1959. Reprinted in *Education Digest,* 25:48–51, January, 1960.

"Implications of Science Education Research on the Training of Intermediate Grade Elementary School Teachers," *Science Education,* 44:35–40, February, 1960.

"A Guide For Instruction in Science" (with others), Curriculum Bulletin No. 19. State of Minnesota Department of Education, 1959. Minneapolis, Minnesota.

"Demonstrating the Basic Operation of the Vaccum Tube," *Minnesota Journal of Science,* 1:29–31, December, 1957.

"Sixth Annual Review of Research in Science Teaching" (with Ellsworth S. Obourn), *Science Education,* 44:374–399, December, 1960.

In preparation with Nathan Washton, Chapter III, "Science in Secondary Schools," in *Review of Educational Research.*

Membership in organizations include:

Professional: Phi Delta Kappa, Kappa Delta Pi, National Education Association, American Education Research Association, National Association for Research in Science Teaching, American Association for the Advancement of Science, National Science Teachers Association, National Society for the Study of Education, Association for Education of Teachers of Science, Central Association of Science and Mathematics Teachers, Minnesota Education Association, and Minnesota Academy of Science.

Social: Tau Kappa Epsilon.

Offices held include:

National Association for Research in Science Teaching Executive Committee, 1958; Vice-President, 1959; President, 1960.

Presently: Committee Man at Large—Section Q, American Association for the Advancement of Science.

Once Held: Chairman—Science Education Section, Minnesota Academy of Science.

Chairman: Subcommittee on secondary school level, Review of Science Education Research, National Association for Research in Science Teaching.

Chairman: Review of Science Education Research, National Association for Research in Science Teaching.

Committee Member: Minnesota State Department of Education, Science Curriculum Guide.

Committee Member: Minnesota State Department of Education, Certification of Junior High School Teachers.

Committee Member: National Science Teachers Association Research Committee.

Member of Writer's Project: American Geological Institute, "A Sourcebook for Teachers," Duluth Conference, 1959.

Dr. Boeck is a Fellow in the American Association for the Advancement of Science and is listed in "Who's Who in American Education."

As regards to his present activities and philosophy of science teaching and education, Dr. Boeck summarizes as follows:

As head of the science department [illegible] University High School, I coordinate the work of

the department, its teaching, curriculum development, and research. I also teach at least one high school class each year. I have taught chemistry and physics, I introduced geology as a seventh grade course eight years ago, and I'm now teaching a course in physical science for tenth graders. The introduction of the Earth Sciences was the forerunner and initiator of considerable curriculum revision in junior high school science in the Twin City metropolitan area. I have taken considerable satisfaction from these changes carried from the campus school into public schools by young teachers whom I've had as student teachers, members of my "methods" class, and as advisees.

My college teaching load consists of a course in "Teaching of Secondary School Science" for science teaching majors and a similar course for science minors. I also have taught "Science Teaching in Elementary Schools" in regular college classes and through the Extension Division of the university.

Also, my responsibilities are graduate school courses: "Advanced Course in the Teaching of Science" and "Problems in Secondary School Curriculum."

Present research activities lie in a Title VII grant of NDEA through the U. S. Office of Education extending over a three year period. As one of three investigators, I am engaged in preparing kinescope film recordings of science teaching procedures involving a variety of techniques and teaching equipment. These are intended for both pre-service and in-service teacher preparation and improvement. Work with Closed Circuit Television has been a part of my work over the past half dozen years.

I believe that everyone has a responsibility to carry out his assigned tasks to the best of his ability. This can be accomplished only with the best of preparation and a subjugation of his biases as bases of choice in favor of choices based on an objective evaluation of all the evidence available. In fact, one should constantly seek new evidence to supplement that already available.

In translating this view to my work as a science educator (and to science educators in general), I feel my major task is that of providing the best possible science education for *all* future citizens whether or not they are to be scientists. In my present position this is possible in two ways. My high school work gives me direct contact with adolescent youth and secondary school teaching opportunities. I am kept pretty honest in what I suggest about science teaching, for I am provided with both the opportunity and responsibility to back up what I say by my own high school science teaching and research. In a second way, I have an approach through the teachers I prepare, to encourage and assist in the improvement of science teaching beyond the campus scene.

Science teachers and curriculum workers cannot afford to become preoccupied with only the addition of the new content of science, the arrangement of the content, or the selection of content for the intellectually gifted. They must also give attention to other aspects of instruction such as improved teaching methods and equipment for science teaching. They must keep in mind the "general education" purposes of the secondary schools.

Certainly encouragement must be given to innovations concerned with new curricula and teaching methods. However, innovations should not be accepted without careful testing. Change for its own sake must give way to change which is based on proven value. In my estimation, proven value is established only through carefully designed, controlled research which includes the most modern, appropriate, and rigorous statistical analysis. Of the latter, we have seen very little.

Finally, I have concern about the time lag encountered between research and its implementation in the classroom. This is partly due to the need for making quicker and clearer interpretation for practicing teachers. It is also a consequence of a reluctance to accept the findings of research as a basis for change. Through my college course in education, I have an opportunity to try to overcome both for each new group of teachers in preparation.

We first came to know Dr. Boeck in 1941 when he became a colleague of the writer at Oklahoma State University. At this early date in his initial start as a college teacher, Dr. Boeck gave every evidence of becoming one of America's most competent science educators. His enthusiasm, thorough class preparation, and fine sense of responsibility, then manifest, has carried over into his work at the University of Minnesota. To be called back to one's alma mater, especially when it has a high international status as does the University of Minnesota, indicates a competence, abilities, and promise, beyond those of the usual young professor. We sponsored his membership into the National Association for Research in Science Teaching and rarely has anyone made so rapid a rise to a place of national recognition and to places of great responsibility within the organization. His fellow members know that when Dr. Boeck is given an assigned responsibility the assignment will be carried out promptly and at a high

level of accomplishment. A researcher of the highest order, Dr. Boeck readily agrees with this observation credited to Justice Oliver Wendell Holmes "Nothing is more rewarding than a searching reexamination of the obvious."

Great as have been Dr. Boeck's accomplishments during the past two decades, the quarter of a century that lies ahead should be characterized by even more rewarding and significant contributions to better science teaching in the future tomorrows.

It is with honor and distinct pride that the Twenty-Fifth Science Education Recognition Award is made to Clarence Harry Boeck.

CLARENCE M. PRUITT

THE USE OF ECOLOGY IN TEACHING SCIENCE TO CHILDREN *

BETH SCHULTZ

Western Michigan University, Kalamazoo, Michigan

I. ECOLOGICAL CONCEPTS IN EDUCATION

MAN'S curiosity about his environment —his need to form a concept of his position in the universe—has motivated observation and interpretation. As he gains knowledge about the physical and biological units of the universe, man forms concepts about them and discovers these concepts to have common elements.

The following discussion will show that similar generalizations can be drawn from views of the nature of the universe, the earth as an environment for living organisms, and the nature of living organisms, including man. These basic factors are seen also in democracy, a social organization invented by man, and in the democratic approach to the educational process.

Nature of the Universe

The gross structure of the universe is one of related parts. The great chunks of matter in space tend to become more or less spherical, and occur in aggregations (galaxies), the members being held in proximity to one another by forces, some known, some hypothesized. One hypothesis, supported by interpretations of observations, is that the universe is expanding or dispersing. The galaxies are receding from one another, indicating a change in the universe from a greater to a lesser gross density.[1]

A recent theory of "continuous creation" proposes that celestial bodies are being formed continuously through condensation of rarified matter of interstellar space.[2]

Whatever their origin, these bodies are sufficiently similar that generalizations can be made about them; yet they are sufficiently unique to be individually charted and identified. These bodies are not static in composition or behavior. Energy and matter are in constant flux, and the energy-matter relationships within and among the celestial bodies are constantly changing.

* Based in part upon a paper presented at the Thirtieth Annual Meeting of the National Association for Research in Science Teaching, Hotel Claridge, Atlantic City, New Jersey, February 15, 1957, but extensively modified by later teaching experiences. Based on doctoral study completed at the University of Florida, Gainesville, Florida.

[1] Sir Arthur Eddington, *The Expanding Universe*. Cambridge: The University Press, 1933.

[2] Fred Hoyle, *The Nature of the Universe*. New York: Harper, 1950.

Man's present knowledge of the physical universe supports the following generalizations:

1. *Individual Uniqueness and Variation:* Individual units of matter differ in a variety of ways.
2. *Interrelationship and Interaction:* Every unit is in some way related to one or more other units.
3. *Change:* The universe is dynamic; individual units are constantly changing; thus the relationships among units are constantly changing.
4. *Continuum:* By virtue or origin and nature of energy-matter relationships, all masses in the universe form a continuum in time and space.

Earth as an Environment for Living Organisms

Earth's uniqueness is more familiar to us than that of other celestial bodies. The composition and proportionate quantities of atmosphere, water and solids, and the limited fluctuations of radiant energy (heat, light, et cetera) permitted the establishment of life and its evolution to the forms now known.

A shifting of the limits of occurrence of any one of the factors would alter or extinguish life on earth. This is known from laboratory experience (or in the house when one forgets to water the plants) and can be seen in areas where human activities have so changed the environment that the community of plants and animals either has disappeared or is altered radically.

Over the earth's surface are many different environments, and each one supports a unique combination of plants and animals. Organisms which can survive the dryness and extreme temperature fluctuations of the subtropical deserts cannot survive conditions in the temperate deciduous forests. Fossils of tropical rain forest plants, found in temperate zone coal mines, indicate climatic changes to which such organisms could not adapt. By their very existence, organisms alter the environment and become an important factor in determining the types of changes which will occur.

These changes over periods of time, and from place to place at any one time, are not abrupt. If a cross section were drawn from the center of one environment to the center of the neighboring one (that is, if it were possible to locate such centers), no line of demarcation between the two could be found. The physical as well as biotic factors form gradients. For example, it would be impossible to locate a sharp line separating the temperate and the tropic zones, or one separating the woods from the meadow.

The generalizations drawn from observations of celestial bodies are thus involved in this general statement about the earth as an environment for living things. Individual situations are unique, but some common factors and a network of relationships bind all units into a continuum in time and space.

The Nature of Living Things, Including Man

As we examine each species of organism and then individual organisms, the generalizations still hold. The human organism will be the principal illustration.

Morphological and physiological studies of man and other organisms indicate that structures and processes indentical with or homologous to those in man exist in other organisms. There is overwhelming evidence that present life, including man, has evolved gradually from simpler forms over a period exceeding one and a half billion years. The unique quality of man is the particular combination of modifications of basic structures and functions which make up his body. In like manner, each species of organism has unique qualities.

Researches in animal behavior and animal sociology give strong implication that human behavior patterns, individual and social, have their forerunners in other parts of the animal kingdom. All major forms of human organization (leadership-follow-

ership, dominance-subordinance hierarchies, parental care, family, et cetera) can be observed in other animal groups. To be sure, the same combination of social forms does not occur in the society of any other one species. A unique feature of man is his ability to handle greater complexities of organization and a greater degree of abstraction than is within the abilities of other animals. However, man's physical form and his individual and social activities are continuous with those of other organisms in time and space.

Through the mechanism of heredity, each organism begins life with a certain potential for development (genotype). The environment in which this beginning occurs will determine whether the creature will die immediately or continue to develop. If the organism survives, it will use the available materials from the environment which its genetic complex enables it to use. Thus the environment—the physical and biotic factors present—exerts an important influence on the ultimate form of the mature organism (phenotype). This action is reciprocated. Each organism by its food requirements, excretory functions, and other behaviors, is a factor in determining the types of changes which the environment will undergo.

When this idea is applied to each member of a community of plants and animals, it is apparent that the activities of each kind of organism in some way affect the lives of other members of the community. The herbivore is dependent upon the presence of plants; yet if the population of herbivores exterminates the plants, it will exterminate itself as well as affect the population of parasites and carnivores which feed on it. No organism is an entity unto itself. It gives something to and takes something from its environment. These relationships determine the form of the mature organism and affect the chances of individual and species survival. The interactions among organisms and their environment determine the types of changes each will undergo. These interdependencies and interactions give the whole community its dynamic quality.

Further analysis of the human species reveals continued support for the generalizations. No two human beings are exactly alike. Geneticists, physiologists, phychologists, and other specialists have verified our superficial observations. All humans have similar structures, but form and magnitude of structure and function of each part vary from person to person. The result is that each individual looks and behaves differently from every other individual. These variations are, of course, limited; otherwise, there would be no human species. If one characteristic were to be selected as a basis for sorting and typing people, and the measurements of this characteristic were charted, the result would be a continuous line without breaks. There would be a gradient. This gradient would not parallel that formed by any other characteristic.

It has been stated previously that man's behavior patterns form a continuum with the behavior patterns of other animals and that a part of this behavior is determined by an organism's interaction with its environment. We can carry this idea further by stating that man's behavior (or that of any other organism) is continuous with all other physiological functions of his body. (Included in "behavior" are all activities sometimes termed "mental" and "emotional.")

Man has not yet learned to isolate basic factors of behavior or to measure them accurately. This is no reason for believing that mental processes are a department separate from physical processes. It is quite reasonable to believe that man's behavior, thought processes, and learning processes are an integral part of the total functioning organism. Many observations of human behavior support this belief.[3]

[3] Ernest R. Hilgard, *Theories of Learning*, Ch. 9, "Wheeler's Organismic Psychology." New York: Appleton-Century-Crofts, 1948.

Human beings, then, are different from other organisms, although they have many characteristics in common with them. All human beings are similar, but no two human beings are exactly alike. The relationships, the interactions among humans and between them and their environment, are the binding forces which establish the temporal and spatial continuum in which we live out our lives.

The importance of the almost infinite number and kinds of interrelationships to the survival of living things is summarized in this discerning statement by W. C. Allee [4]:

> The probability of survival of individual living things, or of populations, increases with the degree with which they harmoniously adjust themselves to each other and their environment. This principle is basic to the concept of the balance of nature, orders the subject matter of ecology and evolution, underlies organismic and developmental biology and is the foundation for all sociology.

The Nature of Democracy—a Social Structure Invented by Man

By virtue of the unique organization of his protoplasm, man has greater powers to choose his course of action than has any other organism. In fact, he has few if any inherited behavior patterns. Add to this the importance of interrelationships to the survival of a population of organisms. It follows that man's chances of survival increase as he gains understanding of his relationships with the environment and devises a social structure which is consistent with his own biological nature and these relationships.

It is the belief of many people that democracy is, or has the potential of becoming, the social structure allowing the greatest opportunity for man's harmonious adjustment within the species and to the total environment. Perhaps one reason for the strong support of democracy is that it seems to affirm "human nature" more than any other social structure yet devised.

Important characteristics of democracy which can be seen to be consistent with the biological nature of the human organism are these:

1. Democracy depends upon an informed citizenry capable of making intelligent choices. It is the nature of man to think and choose a course of action. In a democracy, each citizen is encouraged to develop this ability as far as possible. All people have both the privilege and the responsibility to be educated in terms of their aptitudes and to the limit of their abilities. All people are expected to share in making decisions affecting the group and it is expected that these decisions will be based on knowledge rather than on mere chance or arbitrarily designated authority.
2. Individual differences are honored. Part of the ethic of democracy is the tenet that every human being has the potential for making some positive contribution to the social group. Thus, one of the goals is to create an environment which allows every member of society to develop to his fullest potential. Since individuals differ, this environment must include a wide variety of opportunities and must be flexible in organization.
3. As human potentials vary, so do other human characteristics. A democratic society assumes these gradients by repudiating artificial barriers between groups of people. Although race and social class strata persist, their elimination is desired, and the barriers between strata are not impassable.
4. Democracy is a progressive way of life. That is, members of its society work toward self-improvement and the improvement of the total group. In these efforts, relationships are constantly changing, giving democracy its dynamic quality.

The need for an ethic—a system of values—becomes apparent as one realizes that choices and decisions can be made only on the basis of a set of criteria. The terms "positive contribution" and "improvement" imply that people in a democracy are concerned with the quality of life as well as with physical survival, and this quality is definable only in the presence of an ethic. A detailed analysis of value systems is beyond the scope of this discussion, but the writer believes that an ethic, to survive and have value, must be consistent with natural forces.

[4] W. C. Allee and others, *Principles of Animal Ecology*, p. 729. Philadelphia: W. B. Saunders, 1949.

It would seem then that a democratic social structure approaches consistency with the generalizations previously made about the physical and biological universe and man. Democracy honors individual uniqueness and variation, interrelationship and interaction, change, and continuum.

Education in a Democracy

Education is society's means of orienting its newer members. Its aim is to improve the chances for human survival under a given set of conditions. In a democratic society, education must include experiences which will help young people to develop the knowledge and skills to deal with problems of human survival and to deal with them democratically.

The questions which arise immediately are these: What knowledge, what skills, what kinds of experiences will achieve these goals?

Knowledge

At the root of all survival problems is the basic concept of ecology: that no force operates in isolation. There is considerable evidence to support the idea that when a total system of forces is operating harmoniously, the whole productivity is greater than the sum of the parts. That is, the whole is equal to the sum of the parts plus the factors of interaction. Conversely, when one or more factors are in conflict, the resultant action tends to be reduced, and is destructive rather than constructive. It follows that man's chances for survival increase as he gains knowledge of natural forces (himself included) and their interrelatedness and learns to work with them and to use them constructively.

An understanding of this abstract generalization (involving skills, information, and insight) can come only through a long series of experiences with objects and their relationships. What is learned depends upon the kinds of experiences the learner has and his reactions to those experiences.

In pursuing goals for education, teachers must be aware that children's ability to verbalize generalizations and to repeat memorized information does not necessarily indicate insight or ability to use the information. Although learning does involve verbalization and memorization, these are only two of many important factors in the learning process. Far too many of children's school experiences seem to be based on the assumption that learning is synonymous with accumulating information and mechanical skills.

Skills

Skills needed by children and adults are those involved in perceiving relationships, analyzing situations, handling problems, and using our society's tools of communication.

Although the learning process is not completely understood, a large amount of observation and research supports certain assumptions. These are consistent with the key generalizations throughout this presentation.

Here are some of the more pertinent assumptions:

1. It is the nature of the human organism to respond to factors of the environment within the limitations imposed by the organism's sensory receptors. The whole organism is involved in the response. A part of maturing is the ability to respond to an increasing variety and range of stimuli.

The organism comes to react selectively to the continuous barrage of stimuli, and what the individual learns is its reactions to the stimuli.

2. Learning takes place when the learner has a need, a drive or a motive (imbalance), and a goal, the attainment of which will satisfy the motive and tend to restore balance.

In the process of learning, the organism responds first to the total situation (mass response). This is followed by a process of differentiation which leads to generalization (mass response) on a higher level. This process is repeated on an ever-higher level of ability to generalize and to differentiate.[5]

[5] G. Lester Anderson and Arthur I. Gates, "The General Nature of Learning," pp. 16–21, *Learning and Instruction.* Forty-ninth Yearbook of the National Society for the Study of Education, Part I. Chicago: University of Chicago Press, 1950.

3. Attitudes and emotions, as well as information and skills, are products of learning. Whether a child responds positively or negatively depends on whether his experiences were need-satisfying or unrewarding, adjustment-facilitating or hindering. The child develops interests and attitudes as a result of his relationships with himself, with other persons, and with his natural and cultural environment.

Prominent in all of these assumptions is the concept of interaction between the organism and the environment. If one considers that individual human beings vary in rate of maturing and in abilities to react to stimuli, one can easily understand that patterns of reaction will be nearly as numerous as individual human organisms.

Experiences. The experiences which adults plan for and with children must be consonant with the goals of the individual as well as with those of society. Too, the planned experiences should be harmonious with forces operating within the individual as well as with those of his environment.

It is possible to plan experiences consistent with the nature of democratic society, the individual human organism, and the natural environment, because certain important factors are common through all.

Summary

1. The universe, in which the human species is striving to survive, and the human being, who needs knowledge of this universe in order to survive, function according to the same fundamental principles:

a. *Variation:* Individual units differ in a variety of ways from other units, although some common factors exist.

b. *Interaction:* Every unit is in some way related to one or more other units.

c. *Change:* The whole (aggregation of units) is dynamic. Individual units are constantly changing. Thus the relationships among units are constantly changing.

d. *Continuum:* By virtue of the origin and nature of energy-matter relationships and organismal relationships, all units of the "whole" form a continuum in time and space.

2. Man's nature compels him to make choices of action.

3. Man's survival depends on his increasing insight into the nature of his environment and on his making choices of actions harmonious with the dynamics of this environment.

4. The ecological approach to problems of interaction among human beings and between the human community and its environment is basic to human survival.

5. Education for these concepts must be consistent with the nature of the human organism and the processes by which it learns.

Man needs to acquire an appreciation of himself in relation to his environment. He needs to perceive himself as an integral part of the total organic community, to recognize himself as an animal having characteristics and problems in common with other animals.

Understandings of interdependencies and interactions among the physical and biotic components of the universe can have both aesthetic and practical survival value. These seemingly divergent needs and values can be served simultaneously through studies which have an ecological focus. These can begin with studies of small plant-animal communities in the school yard.

II. DEVELOPING CHILDREN'S UNDERSTANDING OF PLANT-ANIMAL COMMUNITIES

In any learning situation the teacher must consider the nature of the learner as well as the concepts to be learned. A situation which considers the nature of the learner is one of cooperative planning and working. It is neither the teacher's will cleverly imposed on the children, nor the unguided actions of children doing what they please. It is a situation in which every member of the group, including the teacher, contributes to planning the experiences which the group will have. If children participate in planning the ex-

periences which they will be having, the chances of their understanding the problem and the relationships between their activities and the problem are enhanced.

Hence, a cooperative method of working has two advantages. First, it helps children define the problems in terms which they understand. As problems become meaningful to them, they are stimulated to learn. Second, it makes children's activities purposeful. As children help devise ways of working on a problem, they are also planning activities for which they see a reason.

The teacher is leader, guide, and contributing member of the group. In this role the teacher must know something of the developmental level of the children so that she may help select problems for study which are within range of the pupils' maturity and experience. Her knowledge of children and how they learn must be coupled with knowledge of the subject to be studied, for it is the teacher's responsibility to guide the children's thinking with questions and information which will help them make decisions.

Teachers who consider their own knowledge of biotic communities indequate need not have difficulty finding interesting reading material to enrich their own backgrounds. Among many excellent books are two which are useful to readers unfamiliar with the subject: John H. Storer's *The Web of Life* (Signet Key Book #333) and Ralph and Mildred Buchsbaum's *Basic Ecology* (Boxwood Press, Pittsburgh 13, Pa.)

This article will suggest ways of developing with a group of children the concepts implied in the plant-animal community.

Introducing the Community Idea to Children

Children cannot be expected to become involved in a new study unless it can be related to something within their experience. Most children have not had experiences with plant-animal community concepts. Thus it becomes the teacher's responsibility to introduce new situations and increase chldren's opportunities to understand these relationships. The teacher must initiate the study in a way which stimulates the children's interest and gives them some information which they can use as they participate in planning.[6]

An exploratory field trip is one way of introducing the community idea to children. Before the trip the teacher needs to have selected a site and assembled a minimum amount of classroom and field equipment (e.g., aquarium, terrarium, collecting jars, dipnets or insect nets, paper bags). The purpose of the trip should be specific. It may be to find out what animals are living among the water plants in an aquatic habitat or to find out what plants and animals are living around a magnolia tree. Usually even such a restricted purpose can not be achieved in a single field trip. This kind of trip does, however, focus attention on a limited area which can be described in terms of a dominant plant.

On the field trip the children may collect a few plants and animals and bring them back to the classroom. Collecting is suggested *only* in situations where collected species are abundant. As they observe the living things which they have collected, they will be able to formulate questions which can become the basis for planning further field observations.

'wo other types of field trip have proved successful in stimulating children's awareness of habitat differences. Both are excellent ways of initiating a long-term study. In one instance, a teacher took a sixth-grade class to a small wooded area. She

[6] For detailed description and analysis of cooperative planning and working, see: Pauline Hilliard, *Improving Social Learnings in the Elementary School*, (especially pp. 68–77). New York: Bureau of Publications, Teachers College, Columbia University, 1954.

divided the class into four groups. Each group was supplied with appropriate equipment: insect killing jar, empty jar, paper bag, thermometer, strainer, and knife. Each group was given a card bearing the assignment for that group. The assignments were similar. The group was to go to a nearby spot of a particular type. They were to lay out an area approximately one yard square and explore it for thirty minutes. Each group went to a different kind of spot, so that four habitats were being examined simultaneously: (1) the dry, sandy edge of a roadside, (2) an open field bordering a woods, (3) a shady woods area including a rotting tree stump, and (4) the marshy edge of a small pond.

All of the assignment cards had the same guide questions, making possible a comparison of the results of the explorations:

(1) How many plants do you find?
(2) How many different kinds of plants?
(3) How many animals?
(4) How many kinds of animals? Bring specimens if you can. Keep some of them alive if possible.
(5) How many signs of animals do you find? What kind? (Holes in the ground or in plants, tracks, droppings, et cetera.)
(6) What is the temperature at ground level?

The spots where the groups would work had been selected so that they were all within sight and calling distance of a central point. The teacher was thus able to watch the progress of the work and respond to any calls for assistance.

At the end of the allotted time, the groups were called back to pool their findings. A large chart had been prepared for recording the data. (See below.)

Specimens (one sample only of each abundant species) were taken back to the classroom, and a temporary exhibit of the findings of each group was set up. The chart was used to demonstrate the differences among the habitats. These included differences in observed animal life and temperature. Through questions and discussion, the teacher helped the children to see that there were differences also in amount of light and moisture.

At this point, the children were ready to participate in planning a more detailed study of one of these areas or group studies of all of them in order to make more detailed comparisons. They were able to ask or respond to questions about the plants and animals of each area, questions which pointed toward finding out how organisms are adapted for surviving under various conditions of moisture, light, and temperature, and in relation to one another.

In another type of field trip, the teacher took the class to study a small woods area. The children walked in single file and very slowly, in order to observe as much as possible. One-third of the class were instructed to keep their eyes on the ground. They were to try to see as much as they could: holes in the ground, ant colonies, animals in motion, signs of animal activity

Guide Questions from Assignment Cards	Group I Roadside	Group II Field	Group III Woods	Group IV Marsh

(e.g., leaves with holes chewed in them). The second third of the group were told to observe everything that they could find at the level of their waistlines. The last third did the same thing at the level of their heads. The distance explored was limited to about 100 feet. At the end of the experience, the three groups discussed their observations. There was no attempt to explore or report exhaustively. The purpose was to become aware of the life and living conditions of different strata in a plant-animal community.

Another way of stimulating interest in the community idea involves making use of children's out-of-school explorations. Frequently children will bring to school living things which they have found. For example, in any locality where there are small ponds, the teacher can generally count on having tadpoles brought to school. These may be cared for and observed as they grow, thus furnishing a demonstration of frog development. They can also easily be used to initiate a study of the pond community.

When a child brings tadpoles to school, the teacher may ask him questions like these:

1. Where did you find the tadpoles?
2. Were there many of them where you found these?
3. Were there any plants in the water where you found them?
4. Did you notice any other animals? Any frogs?
5. If there were many tadpoles there, they must have been finding food. We do not know what they were eating. What can we do to make sure that our tadpoles get the kind of food that they require?

The obvious answer to this last question is to go back to the spot where the tadpoles were found and collect some of the water and the plants and other animals that are living in it and bring these back to the classroom in order to set up a habitat for the tadpoles similar to that from which they came. Usually, a teacher will have no trouble motivating a child to do further exploring in an aquatic habitat. With a vegetable strainer and a few jars, the child will be able to obtain an adequate supply of the pond water and samples of most of the smaller plant and animal life associated with the tadpoles. When filamentous algae (pond scum) are collected, microscopic animals and other microscopic plants will also be acquired. Thus, while creating a natural habitat for tadpoles in the classroom, the group will also be simulating a small pond community. While the children are observing the tadpoles, their attention can be directed also to some of the aquatic insects and other animals. In this way, an on-going study can be initiated.

If the children have previously studied a human community, the teacher may be tempted to use it to relate the plant-animal community idea. This type of comparison can be useful only if its limitations are understood. If care is not taken, however, its use can lead to misconceptions. Generally, human community studies consider only one kind of animal—human beings. All biological community studies are concerned with many kinds of plants and animals. Thus there is nothing in the biological community to compare with the grocer, the doctor, or the policeman in the human community. Comparisons which could be made at a more abstract level may be difficult for children to understand.

One group of children began to grasp the community concept when they discussed ideas such as these:

1. Every member of the community contributes something to the group and gets something from the group.
2. All of the food which community members eat must be manufactured in the community or brought in from outside.
3. Community members have ways of surviving unfavorable conditions such as extreme heat or cold or extremes of wet and dry.

In discussing these ideas, children may begin to analyze the ways in which humans meet their own needs and later to shift

their attention to the ways in which the needs of animals and plants are met. In these discussions, children learn that all organisms have certain basic needs which must be met if they are to survive and that though the needs are similar for all organisms, the ways of meeting them are quite varied.

Some motion pictures and some types of children's literature have a sufficiently ecological approach to be useful in supplementing the experiences which introduce children to the community concept. While these indirect sources should never take the place of direct experiences, they do provide information and stimulate children's interest in doing more field and classroom observation.

Planning the Community Study

The Teacher's Preplanning. Preceding and during exploratory experiences, the teacher realizes that a study of this kind must involve using field experiences, keeping living organisms in the classroom for observation, and developing some organized plan of study. Because the teacher realizes that these experiences are important for understanding relationships in a plant-animal community, she finds preplanning necessary.

Careful preplanning will help the teacher to understand the scope of the problem. She will be able to predict some of the needs which will arise, because she knows the children and has investigated the resources in the community. As she works through a plan, she will be able to estimate what concepts are to be developed, what learning is to take place, what materials and what help with skills the children may need.

Assembling Reference Material and Resources. Although it is unlikely that there will be any sources of information organized around the specific study which the children will conduct, there is an increasing number of children's books based upon ecological concepts. Good conservation literature is also ecological literature, and sometimes literature on local conservation problems is available from state conservation agencies. In many communities there are amateur naturalists who might be called in to help with specific problems as they arise. The teacher should be familiar with a few resources—field guides and other books, films, local people—before initiating a long-term study.

Assembling Equipment. Before a study begins, the teacher should assemble some of the essential equipment needed for collecting in the field and for keeping live plants and animals in the classroom. Nearly all of the equipment needed can be acquired at low cost. Much of it costs nothing. The largest investment is the aquarium. Terraria and insect cages can be constructed from scraps and inexpensive materials. As the study proceeds, children will collect gallon jars from cafeterias and restaurants and bring small collecting jars from home.

Locating Study Sites. In order to plan field experiences, it is important that the teacher survey the community for possible sites. If exploratory field trips are to be taken, the teacher can plan those so that they will include most of the available sites. In this way she will be helping children gain enough experience and information to enable them to make choices.

Taking Groups on Field Trips. As schools have become centralized and larger, more people are involved in any school project, and administrative problems increase. Because of the difficulties encountered, many teachers have tended to neglect including field experiences in the curriculum. Consequently, many children are not accustomed to field study and do not know how to use the out-of-doors for study purposes.

Even though the class is a large one, it is sometimes desirable to limit the size of a field trip group to four or six children and alternate groups so that all children have opportunity to participate in the field

studies. In some schools an assistant teacher-floater is available to supervise classroom activities while the regular teacher leads the field trip.

Small groups of children who live in the same neighborhood can make after-school explorations. These children can work out plans for their trips during school hours when the teacher is there to help. Parents should be informed of this type of planning so that they will understand that all homework is not book work.

If it is necessary to take an entire class on the same field trip, cooperation of other adults is helpful. The adults as well as the children must participate in the planning; then each adult can supervise a small group of children. The job to be done by each small group needs to be clearly defined and understood.

Helping Children Get Ready for Field Studies. If children have not had field experiences, they naturally associate "going-out-of-the-classroom" with recess and free play. Children need to learn to discriminate between going out to play and going out as a work group to do a specific job. This ability to discriminate is learned gradually. Wise teachers initiate brief field experiences early in the child's school life. Perhaps a cocoon is found on one of the bushes near the entrance of the school. The group will go out for a few minutes to examine it. Perhaps there is an eroded bank a block away from the school. The children spend fifteen minutes examining it. A series of experiences of this kind helps children to understand how to use the out-of-doors to find out some things they wish to know. When they have gained this understanding, they are more ready to participate in a long-range study which must involve many field experiences.

Meeting Problems in the Field. Undoubtedly, some plans will be altered as the study proceeds. Perhaps the purpose of a field trip is to find out what animals live in certain specified areas. If the children cannot find any life whatsoever in these particular places, they may become discouraged and impatient. Unless the teacher can suggest alternative questions and activities, the trip may quickly deteriorate into a discipline problem. For example, a group was studying a nearby roadside ditch which usually contained water and an abundance of cattails, pickerel weed and water hyacinths. Such a site is interesting to children because it is usually possible to find a greater abundance and variety of living things in wet areas than in dry ones. During a long interval between trips, there had been no rain. The water in the ditch had evaporated and the water plants had been left perched upon the rapidly drying mud. The next time the children went to explore, the animals which they had found previously seemed to have disappeared. The children were at first disappointed; then they began to be bored and restless. This field trip could have been a failure, but the teacher was ready with questions and suggestions like these to direct the children's attention to important ideas.

Where might the animals have gone?

Perhaps some of the insect nymphs and larvae transformed to adults and flew away. Perhaps they dug deeper into the mud. Let's dig into the mud to see what we can find.

Let's take some of the mud back to school and put it into water. Perhaps we can find the animals that way.

The ditch had been bordered with cattails and pickerel weed, tall plants rooted in the bottom mud. These can survive drier conditions than can water hyacinths. The teacher asked:

Have the cattails grown closer to the center of the ditch than they were two months ago?

Since no measurements had been made, the answers were only estimates. The group thought so, but could not be certain. The children saw the need for a map of the area which showed the dominant plants and the areas which they inhabited. The teacher continued:

Do you suppose that the cattails and pickerel

weed will eventually cover the area where the hyacinths are now?

Let's look closely at the hyacinths and try to figure out how they have been affected by the drought.

Questions and suggestions such as these introduce the idea of succession or of an organism's limits of tolerance of various environmental factors. They can lead to further interesting work. After a week in which there were several heavy showers, the children were eager to return to their study plot to find out what changes had taken place.

This incident shows how a teacher makes on-the-spot changes in direction in order to turn a situation from a possible failure into a stimulation of further work. It shows also how a teacher can guide the direction of children's thinking and at the same time involve them in planning further work.

Children Plan with the Teacher. In planning, the teacher's goals will be long-range goals in terms of concepts and generalizations. The children's goals are more likely to be immediate and specific.

It is unlikely that children will be able to perceive the gross structure of a community, especially if this type of study is new to them. It would be a mistake to impose a total outline on them. They will gradually understand as they proceed. It is the teacher's job to focus their attention around basic ideas inherent in specific experiences. The amount and range of planning which children can do depends on their previous experience as well as their age. The teacher needs to understand the developmental level of the children and not push them toward decisions of which they are incapable.

The following illustration shows the relationship of the teacher's long-range plan to the pupils' participation in the development of the on-going study. It points out, too, the specific nature of the children's comments and questions:

A group of sixth grade children had had some experience with the community idea and had been on some field trips. They had not had extensive experience in cooperative planning. In the process of planning a new community study they had been asked what plant-animal community they might choose to study. One child responded, "Catch bugs"; another wanted to study the spiders. Only one child of this small committee responded in terms of the question, and he said they could study the woods. The teacher picked up this last response but also honored the others. "We found bugs and spiders in the other community we studied; where might we look for these in the woods?" Responses came rapidly. The children began talking about what they might find in the woods and where they would look for animals.

These children were not able to make an over-all plan. But the teacher was able to help them organize their specific suggestions into a plan of action.

Selection of a Community for Study. After exploratory experiences have stimulated children's interest and given them some basic knowledge, the children will be ready to select a community for study. Criteria for selection of a community involve both limitations and possibilities. Since community concepts can be demonstrated in almost any habitat, the biological possibilities are nearly limitless.

The limitations of choice are mainly those of accessibility and safety. It is impractical to consume more time getting to and from a site than in studying it. Field study sites are easily found in rural areas. Although sites are fewer in densely populated areas, back yards, parks, and vacant lots should not be overlooked.[7] Even the unkempt areas along sidewalks contain interesting material. A clump of bamboo in a vacant lot in Gainesville, Florida, provided material for a study lasting three months.

In selection of a site for study, the knowledge and interests of the teacher are important factors. A teacher will have more enthusiasm and be better able to guide children's studies in an area with the problems and phenomena of which she is familiar.

[7] Beth Schultz, "Urban Biology—an Ecological Approach," *Amer. Biol. Teacher,* Vol. 22, pp. 148–152, March, 1960.

The safety precautions which need to be taken are an important consideration. These will depend partly on the age of the children and partly on the nature of the area. Many opportunities for field experiences are lost because of unwarranted fears. The attitude that one avoids hazards by never going where dangers exist is a fallacious one, for some danger is always present in the cultural as well as the natural environment. Children learn to obey traffic laws, and they learn to use sharp tools. One basic principle of safety, thorough knowledge of the hazard, helps to eliminate fears. It applies to plants and animals of the natural environment, as well as to instruments of the culture.

Children can be helped to understand the limitations involved in selecting a site for study. They can then participate in the listing of possibilities and in making the final decision. Exploratory field trips, such as those described earlier, can help children take the guesswork out of their decision making. They will know whether it would be best to study an aquatic or a terrestrial, a shady or a sunny place. They will be able to judge whether they all should study the same site or divide the class into groups in order to study several sites comparatively.

Some Ways in Which a Community Study May Develop

The specific ways in which a community study develops vary from one situation to another. The interests and background of both teacher and children and the available sites for study are only a few of many variable factors. However, some common problems and trends are predictable.

The following descriptions illustrate some of the ways in which a study of a water hyacinth community developed in two grades—second and sixth—in a semi-rural Florida school. Some of the methods described here could be used in other types of situations. For example, only four or five children went on each field trip with an assisting teacher while the regular teacher remained at school with the rest of the class. The groups were rotated so that every child would have at least one opportunity to go on a trip.

In the second grade, the first field trip came after only brief discussion of the community idea. The teacher had decided to take the children to an area of water hyacinths where the water was shallow and the hazards were at a minimum. On this trip the children gained experience which was useful to them in future planning.

The group took with them a minimum of equipment—a large screen, a few small strainers, collecting jars, and a household thermometer. The purpose of this trip was to explore the water hyacinth community to find some of the animals living there and to examine their habitats.

When the group arrived at the site, the teacher and another adult assistant scooped up a large clump of hyacinths with the screen. As the water drained from this mass, an abundance of different kinds of animals appeared. The children were excited and enthusiastically set to work "catching things" with their small strainers. The teacher directed their attention to collecting under and among the roots of the hyacinth plants.

Samples of the most abundant animals were brought back to the classroom and transferred to an aquarium and gallon jars. The experience was shared with the rest of the class by a short report from every child who had gone on the trip. One child demonstrated how they had used the strainer for collecting. Another child told about taking the temperatures of the water and the air. The other children showed the animals which they had brought back.

The aquarium and jars were placed on a table where children could watch the animals. The pupils became interested in

trying to find out how the various animals (most were aquatic insects) breathe. Since all the adult insects are air-breathers and many of the immature insects are gilled, the children had opportunity to observe both. They began learning that respiration involves getting oxygen—that oxygen is a part of the air, not all of it—that water contains dissolved oxygen—that some animals get their supply from the air and some from the water.

In order that all the children would have opportunity to observe, the teacher helped arrange the daily schedule so that small groups had several minutes per day around the aquarium table. During free periods, individual children spent time observing. Since seven-year-olds are not proficient penmen, note taking was not demanded. However, new words were added to the vocabulary as they came into use—oxygen, beetle, tadpole, et cetera. These words were written on the blackboard and used often in the experience charts. The children enjoyed using the new words and talking about these animals which they could now call by name. During this experience the teacher was able to reaffirm earlier observations that big words are not difficult for children when the children have meanings for them.

One of the concepts usually developed in the second grade is that of temperature. This, of course, is accompanied by acquiring skill in using the thermometer. Through the experience of studying the water hyacinth community, what might have been a chore, became a demand on the part of the children. They were delighted to use the thermometer because they had a reason for using it. They now needed to keep records of temperatures of the water and the air each time they went on a field trip. Following is the teacher's account of the children's introduction to the use of the thermometer:

> The thermometer was introduced to the second graders during a November field trip. Realizing that the children knew very little about thermometers, the teacher measured and recorded the temperatures of air and water. She made no effort to have the children watch the process but merely made some comment on what she was doing. Only one child watched her; the others were busy with their own investigations. After a while this little girl got the thermometer, put it into the water, then looked at it. She was imitating what she had seen. The teacher noted this, went to her, and pointed out the red line in the glass tube. She blew on the bulb of the thermometer and showed the child that the red line went up. Then she put the thermometer into the water and they watched the red line go down. The child was fascinated and spent the remainder of the time experimenting with the thermometer. On the way back to school, all of the children became involved with this experiment. They held the thermometer out of the car window and watched the red line go down. Then they blew their warm breath on it and watched the red line go up. All of these children learned to associate the "down" of the thermometer with cold, and the "up" with hot.

Within two months several of the children could take water and air temperatures when they went on field trips. By the following March the whole second grade group was keeping a daily record of classroom temperatures as well as the records they kept of temperatures in the hyacinth community.

The classroom activities of a sixth grade were somewhat similar to those of the second grade, but the twelve-year-olds were able to do more of the planning. A committee of children planned the rearrangement of the furniture to enable them to put their large table by a window where the aquarium could receive sufficient sunlight. They arranged chairs around the table, divided the class into small groups, and set up an observation schedule. These children took notes of what they saw.

The notes were used by the teacher in several ways. Difficulties in spelling were noticed and a spelling lesson evolved. The notes indicated an opening up of new questions and a need to learn to distinguish between an event and a conclusion drawn from the observation of the event; e.g., "tadpole learning to breathe." The teacher composed a guide based on the notes which the children had made. It was duplicated and a copy was given to each child. The

purpose of this work sheet was to help children summarize their classroom observations and to pose questions to stimulate further observation.

In these situations the field activities gave the children the opportunity to:

1. Observe the nature of the habitat, compare it with other habitats, and observe seasonal changes.
2. Observe organisms in their natural environment and associate specific kinds of animals with their specific habitats.
3. Devise ways of keeping living animals in the classroom for observation. Observations of the natural habitat gave children information needed to simulate natural conditions in the classroom cages.

The classroom activities gave children the opportunity to:

1. Observe the structure of the community. The aquarium contained water hyacinth plants and some of the animals which were found among them. The children could see the layering of the community and observe which animals confined most of their activities to which layers. They saw some food relationships, for they observed both herbivores and predators in action.
2. Observe individual animals. The children could see how the animals used their appendages for locomotion, food-getting, and protection. They learned something of the development of animals. The second grade teacher stated that although the children were familiar with both the nymph and adult damsel fly, they never fully perceived the relationship until the day they watched an adult emerge from the nymph stage. The children were actually awe-stricken. "That big thing came out of that little thing?"

In addition to making progress toward understanding the relationships within a plant-animal community, the children were learning many other things. They were increasing their reading and speaking vocabularies as they needed new words to describe their experiences. They improved their skills in spelling, writing, and number work as they needed these skills in keeping records. As they discovered new objects, they asked questions. They defined problems, analyzed them, and in attempting their solution, planned procedures. It becomes obvious, therefore, that it is impossible to work through any study which does not demand the use of all of the basic skills of communication.

Keeping Records of the Community Study

It is important to keep some kind of record of a community study which continues over a long time. When planning the kind of record which is to be kept, both the teacher and the children need to be well aware that the kind of record one keeps depends on what one wishes to find out.

Since children generally are concerned with immediate specifics they are not likely to be able to plan a system of record keeping when the study is initiated. They will not understand what kinds of data to accumulate in order to learn about distribution, change, and interrelationships within the community. It is the teacher's responsibility to help children learn how to make decisions concerning what to record and how to record it.

When the sixth grade group studied the water hyacinth community, a system of record keeping developed gradually. During the first field trip in the early fall, the children were most excited about the number and variety of animals. They had little interest in recording the temperatures, for they were not able to understand the significance of this information. Knowing that temperature records would become important as the season changed, the teacher had the children spend only a few minutes reading temperatures and she recorded them in her notebook. The remainder of the time was spent investigating and collecting samples of the animal life among the hyacinths. The children did not know many of the animals and were constantly asking, "What is it?"

When it was time to return to school, the group gathered at the car, and the teacher helped them summarize their findings. She took out her notebook and recorded the children's answers as she asked, "What animals did we find among the hya-

cinth roots?" ". . . on top of the leaves?" "... in the mud?" "... Among plants other than hyacinths?" Then she asked each of the children what he would like to report to classmates when they returned. In this way, each child was able to report on the part of the experience which had impressed him most and the teacher was able to make suggestions to those who had some difficulty deciding what to report.

Back at school, the teacher took notes as the children reported. When school was dismissed, a few children remained to help put the collection of animals into the aquarium and gallon jars. These children watched as the teacher copied the field notes and the reports into a large looseleaf notebook. The notebook was left by the aquarium, and the children were asked to write into it the things they observed from day to day.

After several days, it became apparent that the children needed more help in recording observations. They had recorded some interesting events such as a leech killing a small fish, but there was no indication of when or how this had occurred. The children discussed the problems they had encountered in making observations. Most of them agreed that they did not have enough time to watch the activities in the aquarium. Consequently, the class divided into small groups with scheduled observation times during which notes would be taken. Within a short time, the notes had better organization. Field trip and classroom observations were entered chronologically. A form for recording field observations was devised and mimeographed. It included these items:

Date:
Time:
Members of the group:
Temperatures: (with enough space to record temperatures of four or five locations)
Description of places and list of plants and animals found in each place. Tell whether animals are big or small, many or few.
Other observations:

As the second graders studied the water hyacinth community, their record keeping was less formally organized. The children who went on field trips, planned their report to the class before they got into the car to go back to school. These children were keen observers of the activity in the aquarium, and the teacher helped them record their observations on experience charts and in the pictures they drew.

The records of field trips helped the children of both groups draw some tentative conclusions about the plant-animal community. A list of the animals found during each trip focused attention on individual community members, their habits, and developmental stages. The lists also pointed out the variety and abundance of living things. When the lists were coupled with the temperature records and notes about the condition of the plants over a period of several months, it was possible to draw conclusions about associated phenomena.

Evaluation

Evaluation takes place continuously as the study develops. It is a continuous process of considering "where we have been, where we are now, and where we are going." Planning involves discussion of previous experiences, and these discussions usually result in further planning. Children can measure their own progress as they express satisfaction in new knowledge. The teacher estimates pupil progress as she notes ways in which her pupils respond to new problems and situations.

Planning Involves Evaluation. After children have had some field experiences and have kept some plants and animals in the classroom for observation, questions arise and new interests develop. Sometimes a small group of children will want to study a specific group of organisms or attempt to find the answer to a specific question. Perhaps a child will wish to

work alone on his new interest. It is possible to organize the schedule and the class so that groups and individuals can work simultaneously on different specific interests.

After several field trips, the sixth grade children began to focus their interest on special problems. Field trips were planned so that each child was able to work on his own problem. On a field trip to the canal, five children were working on three different aspects of the water hyacinth community. One child was collecting different kinds of aquatic plants. Two boys were interested in the vertebrate animals, and two other concentrated on the insect life. The children's planning for this field trip was also an evaluation of their previous experiences, their records, and their understanding of purposes of the study.

When a field trip is being planned, the teacher may begin the planning session by asking children what they want to find out during the trip. The children will be thinking of things they had found out previously and their suggestions will be based on that experience. A group of sixth graders wanted to return to exactly the same spot which they had visited before. Some weeks had elapsed since their last field trip and they were interested in finding out what changes had taken place. One boy suggested that they examine animal life around water hyacinths which were growing in different situations—single plants floating in deeper water, mats of hyacinths near the shore, and plants in the mud where the water level had gone down. These children were beginning to be able to express ideas about habitat differences and changes which occur in any one place over a period of time. Teacher and children alike became aware of their progress as they planned a course of action.

A Child Evaluates His Own Progress. During a field trip in late spring, an eight-year-old was examining a mass of water hyacinth roots, picking out insects, crustaceans, and other small animals. He said to the teacher, "I'm not afraid to pick up these things like I used to be when we first came out." He had lost his fears and was expressing satisfaction in overcoming fear as well as giving the teacher evidence of what he had learned.

The Teacher Evaluates Pupil Progress. After two groups of second grade children had gone on field trips to investigate life around water hyacinths, had brought back some of the plants and animals and had told the other children about their experiences, the teacher asked all of the children to draw pictures of the water hyacinth community. These pictures revealed the things which had impressed the children.

One picture showed a large number of individual hyacinth plants. The child had perceived the mat as being composed of many plants. Most of the pictures showed a large green mass with many small leaves sticking out of the top and the roots hanging from below.

Several children who had been impressed with the large hollow cells of the hyacinth leaf petioles drew little black circles all through the green masses. These, they explained, were the air spaces that made the plant float.

Most of the drawings included many animals. Some of the children had been impressed with the "hot bugs," the only insect in this habitat which can inflict a painful, although harmless bite. This insect is green and not very conspicuous, but on the pictures the children frequently colored it bright red.

Most of the pictures showed that the children had noticed that different animals are found in different parts of the community. Tadpoles swam in the open water. Most of the insects were near or among the roots of the hyacinths, and crayfish were on the bottom under the roots. All of the pictures showed the water level, the green parts of the plant above the water, and the roots submerged.

The children would not have gained

these concepts without direct experience. The pictures were definite evidence that these experiences had resulted in real learning on the part of the children.

Throughout the study of the water hyacinth community, evaluation took place with the second and sixth grade groups as the children:

1. Used new vocabulary in speaking and reading.
2. Posed questions which arose as a result of their experiences.
3. Analyzed situations.
4. Reported on a field trip and planned for the next trip.
5. Attempted to analyze classroom situations in which animals died and set up new situations which might overcome the difficulties.
6. Became interested in special problems and pursued individual projects.
7. Planned studies of new communities to compare with those they had already studied.

Summary

Educational psychologists have demonstrated that a good learning situation is one in which children become involved. Involvement can occur if children are able to relate new problems for study to their own experience and their own needs. Children will become involved also as they participate in defining the problem and planning the course of action.

In studying the plant-animal community, the child is working toward understanding vital concepts through experiences in his own environment. If he participates in planning the experiences, and the experiences are meaningful to him, no part of the study will be too remote or too abstract.

A child will learn specific factual information more readily if these details are important to the solution of a problem, or if they can be related to a whole configuration in which the child is interested. In the study of a biological community, the structure, function, and development of an individual animal are determining factors in the relationships of the animal with other parts of the community. They are not isolated phenomena. As the children study the community, they are constantly shifting their attention from the whole community to an examination of its parts. As the association of the parts with the whole its continued, relationships are more readily understood.

Throughout the study, there is no need for all of the children to study the same specifics. Specific studies of structure, function, and development relate to the same habitat. Special interests of children can be encouraged as a community study evolves, for all individual studies can be pooled and a better understanding of the total community can result.

In the study of a biological community, as with any other project in which children become involved, children improve their use of the basic skills of communication and analytical thinking.

ADDITIONAL EXPERIMENTAL EVIDENCE SUPPORTING KORZYBSKIAN PRINCIPLES *

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INTRODUCTION

If one were reporting research in pre-Galileoan days, a bibliographical item referring the reader to Aristotle would have been enough to substantiate a statement, whether or not it conformed with processes in the observable world.

In pre-Einsteinian days a researcher could refer to Newton's laws or Euclid's axioms to validate his argument. But we now know that these laws and axioms hold strictly only for a hypothetical "Euclidian Space," and that the world as we now know it can be described more adequately by non-Euclidian geometry. At one time a researcher could rely on Dalton and his concept of "indestructible atoms," yet today atoms are being destroyed, and this formulation has been proved inadequate.

Thus, the theories of Aristotle, Newton, Euclid, or any authority are only tentative and subject to revision when empirical testing demonstrates such a need. In science the tendency to be restricted, by pronouncement of authority, is less noticeable than in many other areas. This is in part, due to the definition of science. To some science represents a specific body of knowledge, to others it is a method of operation. Perhaps the most fruitful way of looking at this discipline is to consider it both a body of knowledge and a *modus operandi*. Considerable evidence exists that this latter definition is one to which the majority of science educators adhere. If this is true one would expect that those in science education would behave as scientifically outside their laboratories and classrooms as they do within them, thus setting an example for their students. There is some evidence, however, to indicate that this is not always the case. For example, each of you will undoubtedly know instances when your colleagues or yourself have become embroiled in argumentation or heated debate about some philosophical issue for which no operational questions or procedures can be suggested. It has long been accepted that scientists, more than other individuals, recognize the futility of asking unanswerable questions. If one assumes that the primary value of science is to inculcate the principles of problem solving, then one of the major tasks of science educators is to help students differentiate between the kinds of questions asked and the language used by scientists, in their role as scientists, and the questions and language used by those not trained in this discipline.

The language of science is supposedly more precise, more flexible, and more operational; meanings are more restricted, generalizations are (more) carefully drawn, and the tentative nature of outcomes is more specified. Unlike dogma, in which assertions are final and absolute, scientific statements tend to be gauged in terminology so structured as to allow for change. The language of science, in other words, is structured in such a way that it more appropriately reflects the structure of the real world as it is found to be through observation and experimentation. It may be an over-generalization to say that "the language of science is the better part of the methods of science" but, there are many in this field who accept this contention.

A quarter of a century ago this idea,

* A paper presented at the Thirty-Third Annual Convention of the National Association for Research in Science Teaching, Hotel Sherman, Chicago, Illinois. February 11, 1960.

which had been long sensed as well as expressed by experts in the field, was crystalized by the founder of a discipline known as General Semantics. Unfortunately, this founder was, to a degree, a dilettante. This is not to say that he was not a highly educated, intelligent, and dedicated man. Indeed he was all of these but he claimed he had developed "a unified science of man" and this alienated many who would otherwise have considered his work more seriously. His proposals and claims overstated as they were, seemed reasonable and sound, but they were not subjected to rigorous experimental testing. In fact not until 1952 was anything done, to my knowledge, to either support or refute the contentions of Korzybski. These contentions had, true enough, been superficially validated by gross observation, but from a scientific point of view, this type of observation is insufficient to warrant wide-spread acceptance. Observations are important in the development of hypothesis to be tested. This paper will review the first efforts of testing the assumptions and contentions of the General Semanticists, as well as discuss the most recent research toward this end.

Some of you may remember a paper presented to NARST in New York City in 1955, which described the construction and validation of a test designed to measure variation of identification between socially well-adjusted and socially maladjusted individuals. Identification in that paper, was defined as: "The inability of an individual to differientiate between operations in the universe and his description of those operations." The General Semanticists contend that any form of the verb "to be," without restriction or qualification, ignores the role of the observer in the evaluation of an object, process or event. For example, the statement "The world is flat," implies flatness is an intrinsic characteristic of the world, and at the same time denies—roundness. It was logical enough in 1400 to accept this discription but in 1960 it is known to be contrary to fact. This suggests that language, based on a subject-predicate structure, affirms or denies characterictics of an object. The language of science, on the other hand, does not say "This is the way the world is." but rather, "This is the way the world appears to be." Here the attention of the listener or reader is called to the fact that additional data may necessitate a different evaluation or description. Such a language structure invites further experimentation. It specifically minimizes the use of the "Is of Identity."

Scientists seem to communicate better than non-scientists. They solve problems more easily and their answers have a greater degree of predictability. It seemed possible, therefore, that if identification did, in fact, play a role in problem solving, then measuring the extent of the use of the "Is of Identity" might distinguish between problem solvers and non-problem solvers. Further, if those who solve problems are better adjusted to the world in which they operate the measurement of the use of the "Is of Identity" might also be indicative of social adjustment. This latter was submitted to experimental testing, first in 1952–54, and the results seemed to strongly suggest that with the 516 persons tested between the ages of 12, and 25, those habituated to the use of the "Is of Identity" tended to be more maladjusted than those who were not. A replication study conducted by a different researcher during the years 1955–58, involving 387 individuals, confirmed the results of the first study. Both studies used the "Is of Identity" test to measure identification. This instrument is described in the October 1956 issue of *Science Education,* and in the February 1960 issue of the *General Semantics Bulletin.* Briefly, this test was composed of 100 true-false items, each of which embodied the "Is of Identity." For example, "Women are

mothers," "Boys who never lie are good," and "Iron is strong." Respondents were instructed to mark as true, statements which are always and invariable true. In addition, five self-rating categories followed the true-false statements. Testees rated themselves on a five-point scale with respect to their social adjustment. These items were: "I like almost everyone," "I am very careful in choosing my friends," "I like more people than I dislike," "I make no friends until they prove worthy of my friendship," and "I like and dislike about the same number of people." In each study the analysis of variance was used as a statistical technique and where significance was indicated co-variance adjustment was employed to eliminate the influence of I.Q.

The first study conducted by Weiss [6] and the second study conducted by Hopkins [3], both showed highly significant differences (at the .01 probability level) between the means of the "Is of Identity" test score and self-rating category—"I like more people than I dislike"; between institutionalized and non-institutionalized; and between teacher ratings. These latter were composite evaluations of a student's social adjustment.

Last year further research was presented at the 32nd Annual Convention of NARST at Atlantic City [8]. This research was merely suggestive because it was based on a limited number of cases and tested new hypotheses. The present paper presents some findings of an enlarged study conducted at Arizona State University between the years 1956 and 1959.

THE PURPOSE OF THE PRESENT STUDY

It was the purpose of this study to determine: (1) whether students who score high on the "Is of Identity" test at the college level also score high on intelligence tests, (2) whether college level influences "Is of Identity" scores, (3) whether high scorers on the "Is of Identity" test are more likely to think in operational terms than those who score low, and (4) whether this true-false test led to fallacious results. Previous research tended to indicate that there was very little relationship between intelligence and indentification but there was enough relationship to justify the first hypothesis cited.

SELECTION OF THE SAMPLE

The sample was drawn from students enrolled in the courses entitled: Exploration of Education, Psychological Foundations of Education, and Fundamentals of Teaching. This population consisted of 900 students from which the sample of 200 was taken. Upon entering any of these courses each student was assigned a number. The particular students to be tested were selected by the use of a table of random number. The sample group included 90 freshmen, 50 sophomores, 36 juniors, and 24 seniors.

METHODOLOGY

Analysis of variance was considered the most desirable method of analyzing the types of data gathered. This method tests whether class means differ significantly among themselves when class variances are taken into account. To test the significance of the differences between class means, one compares the variance within classes with the variance of the class means. This is done by first analyzing the total sum of squares of the deviations of the test scores from their grand mean into two parts. The first part is the sum of squares of deviation of test scores from their class means. The second is the sum of squares of the deviations of the class means from the grand mean. Each of these parts divided by the appropriate degrees of freedom gives a separate estimate of the variance of the parent population. The ratio of these two estimates—with the larger as the numerator is the value of F.

This value can be compared to a critical table of F values in a standard F table. If it exceeds the value of the table, the means of the classes differ significantly at the indicated probability level. Co-variance technique can be employed to control the influence of one or another variable or correlations can be determined for those F values that show significance. F values were determined by comparing "Is of Identity" test scores with the Classes of (1) I.Q. (Determined from the Henmon-Nelson Test of Mental Maturity), (2) Freshman, sophomore, junior and senior, and (3) operational—non-operational thinkers. For determining whether the true-false test led to fallacious results a correlation was run between scores earned on the "Is of Identity" test and on a 100 true-false test of entries, entered at random by students. These entries represented pure guessing. In other words, students were given a paper numbered from one to one hundred and were told to enter a T or F in each space at will.

To determine which students tended to think in operational terms a series of 50 questions were given. Thirty operational questions were interspersed with 20 non-operational, vague or non-answerable questions. Students were asked to select only those questions from this series that, in their opinion, suggested procedures for determining an answer. For example, a question which asks, "Is Democracy defeating religion?" is non-operational whereas, a question which asks, "Do those who attend church vote more regularly in a general election than those who do not?" is operational.

FINDINGS

According to the analysis of variance there was no significant difference between those scoring high on the "Is of Identity" test and those scoring high on Intelligence tests. There was a significant difference between freshman, sophmore, junior and senior levels, and scores earned on the "Is of Identity" test. Therefore a correlation was run between class levels and test scores. The correlation was 0.47. At first this finding seemed to contradict the findings of the two previous studies, namely that age, sex, or grade level did not influence the use of the "Is of Identity." Upon closer inspection however, it became clear that a large number of the testees were students who had previously taken the Exploration of Education course at Arizona State University. The primary goal of this course is training in non-identity. Omitting this group from a second correlation study reduced the correlation coefficient to +0.15. This is not significant at the point .05 level. This slight but still positive correlation corresponded quite closely to previous findings, namely, very little relationship exists between intelligence and identification. The fact that any relationship existed necessitated the use of co-variance adjustment in the previous studies.

The analysis of variance showed a highly significant difference between students who think in operational terms and those habituated to the use of the "Is of Identity." A correlation between scores on the "Is of Identity" test and the test devised to determine operational thinking was +0.66.

A simple correlation between scores earned on the "Is of Identity" test and scores earned on the random true-false tests showed no significant correlation. This would tend to confirm the previous contention that the "Is of Identity" tests scores are not a function of chance.

CONCLUSIONS AND IMPLICATIONS

The Korzybskian principle on which this study was based is often called the non-identity principle. It merely states that no object, process or event exactly corresponds with our evaluation of it. To become aware of the lack of correspondence between the world and our verbaliza-

tions about it may contribute to easier understanding and adjustment. Since it is impossible to get answers from unanswerable questions it appears reasonable to assume that training in non-identity contributes to operational thinking. This is based on the finding that students who do not identify can more easily recognize operational questions. It is also based on the finding that students who had had training in non-identity scored higher on the "Is of Identity" test as well as on the operational question test. It would also seem that identification is not a function of either intelligence or education. This conclusion is based on the findings that there was no significant difference between scores on the "Is of Identity" test and scores on the Henmon-Nelson Test of Mental Maturity, or between scores on the "Is of Identity" test, and college level. Finally, the evidence is quite clear that chance does not play an important part in the score obtained on the "Is of Identity" test, judging from the results of this study and the two previous studies reviewed. One of the more interesting outcomes of all studies relating to identification is the subtle suggestion that mental maturity or intelligence may not be the stable, inherent characteristic that we now believe it to be. Although it is true that some alteration of our original attitude toward intelligence has occurred, as a consequence of environmental studies, no rigorous investigation has been undertaken to determine whether alteration on one's language structure might influence mental maturity. If an experimental group of children were trained in non-identity and compared with a controlled group not so trained, it might be possible to discover whether intelligence could be altered by training in non-identity.

There seems to be good reason to believe, on the basis of the findings, of the three studies cited in this report, that science educators might find it profitable to devote considerable attention to the inculcation of the three Korzybskian principles of non-identity, non-allness, and self-reflexiveness. If these studies and the others listed in the bibliography are correct, one can assume that the teaching of science *alone* does not insure that students will operate scientifically outside the science class. In other words, teaching the scientific method in science classes does not guarantee transfer. Since relatively few of those who study science will become scientists, our major task may be, as Craig has said, "To help more students become educated laymen." It is quite possible that Korzybskian principles can help.

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THE USE OF LABELED PHOTOMICROGRAPHS IN TEACHING COLLEGE GENERAL BOTANY *

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INTRODUCTION

LABELED photomicrographs had been used by the writer in an experimental comparison of the "project centered" and "conventional" methods of teaching a college general botany class [6]. The students involved in the project centered class received labeled photomicrographs to assist them in their laboratory work. The students reacted favorably to the photomicrographs and laboratory instruction appeared to be facilitated when labeled photomicrographs were used. On the basis of previous observation, it appeared of value to investigate the effect of labeled photomicrographs on a student's achievement in general botany.

It should be noted that laboratory work in biology classes has been undergoing a gradual evolution with respect to the illustrations made or used in the laboratory. The time honored procedure was to require each student to draw detailed replicas of the material he studied. This approach may have peculiar values, but student drawings require much time and the student cannot study the material while he is engaged in the actual drawing phase of the work. Johnson [4] found that students did as well in college zoology, if not better, when detailed drawings were not required, though students were asked to make sketches. At the high school level, Ballew [1] found that students who were not required to make drawings of materials studied achieved superiorly to those who were required to make drawings or sketches. Taylor [7] found that college freshmen using ready made drawings which they labeled made greater gains than students who drew and labeled their own drawings. More recently, Kiely [5] reported that students who recorded their observations on photomicrographs made greater gains than students who made drawings of histological materials.

The study reported here was an attempt to measure the effect of labeled photomicrographs, supplied in addition to the regular outline drawings in the laboratory manual [3] on student achievement in a college general botany course.

THE POPULATION STUDIED

The experiment was conducted during the spring semester of 1958 with 43 students enrolled in Biology 240, General Botany, at Kansas State Teachers College of Emporia. The class met three times each week for two-hour periods. The first hour was devoted to lecture and the second hour was devoted to laboratory work. Occasionally, the lecture was less than one hour in length and the laboratory period was correspondingly increased in length. General biology or the equivalent was required for admission to General Botany, so all of the students had some background in botany. A standard textbook [2] was used and the most of the topics common in general botany were presented. The lecture was given by the writer to all 43 students and laboratory work was supervised by the writer, though teaching assistants were responsible for much of the instruction in the two laboratory sections. The students were divided at random into two groups. The mean scores for the two groups on a Biology Entrance Examina-

* A paper presented at the Thirty-Second Annual Meeting of the National Association for Research in Science Teaching, Hotel Dennis, Atlantic City, New Jersey, February 19, 1959. A report of research conducted at Kansas State Teachers College during the spring semester, 1958.

tion and the Schrammel General Abilities test, taken upon entrance to the college, were found not to differ significantly. (See Table I) To the extent that these two groups are representative of college general botany students, the results of this study may have applicability. The conclusions should be applied to other science classes only with caution, if at all.

TABLE I

TEST FOR SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS OF THE TWO EXPERIMENTAL GROUPS ON THE SCHRAMMEL GENERAL ABILITIES TEST AND THE BIOLOGY ENTRANCE TEST

Test	Group	Number	Mean	t	Prob.
General	I	20	107.20	1.05	>.05
Abilities	II	17	100.94		
Biology	I	20	66.75		
Entrance	II	18	65.17	.266	>.05

METHOD

The two treatments were (1) laboratory work with outline drawings provided in the laboratory guide and (2) laboratory work with outline drawings and labeled photomicrographs. The procedure in which the treatments were applied is shown below:

First three weeks
Both groups—Outline drawings plus labeled photomicrographs → Test I

Next four weeks
Group I —Only outline drawings
Group II—Outline drawings and labeled photomicrographs → Test II

Next four weeks
Group I —Outline drawings and Labeled photomicragraphs → Test III
Group II—Only outline drawings

Last four weeks
Both groups—Outline drawings plus labeled photomicrographs → Final Test

Each test consisted of two separate parts. One section was given in the laboratory and consisted of identification of structures and similar "practical" questions. The other section of the test was given in the lecture room and this section was composed of objective questions on the facts, principles and understandings of importance in the course. Reliabilities of the tests ranged from 0.63 to 0.95.

FINDINGS

The mean scores and variances were computed for the two groups for the "practical" and "lecture" sections of all tests. During the first three weeks of instruction, both groups received labeled photomicrographs as a supplement to outline drawings in their laboratory guides. A test was given at the end of this time and Group I had mean score of 71.90 on the "practical" test and Group II had a mean score of 70.95 on this test. On the lecture test, students of Group I received a mean score of 76.33 and those of Group II received a mean score of 76.00. The difference between means was not significant on the "practical" and the "lecture" tests (see Table II). Group II scored slightly lower on both tests, consistent with the trend on the entrance tests (see Table I).

TABLE II

TEST FOR SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS AND VARIANCES OF THE EXPERIMENTAL GROUPS ON LECTURE AND PRACTICAL TESTS AFTER THREE WEEKS OF INSTRUCTION IN BOTANY WITH SUPPLEMENTARY PHOTOMICROGRAPHS

Test	Group	N	Mean	Variance	F	t	Prob.
Practical	I	21	71.90	248.1			
Test I	II	21	70.95	135.95	1.825	.222	> .05
Lecture	I	21	76.33	140.35			
Test I	II	21	76.00	128.1	1.096	.092	> .05

During weeks four through seven, only Group II received supplementary labeled photomicrographs. At the end of this period, Group II had a mean score of 70.60 on the "practical" test and 61.52 on the "lecture" test. The "practical" mean was 4.30 points higher than the mean for Group I and the "lecture" mean was 1.76 points higher. The differences in mean scores for Groups I and II were not significant, however.

From the eighth through the eleventh week on instruction, only Group I received labeled photomicrographs. After this period, the mean score for Group I on the "practical" test was 63.37 and on the "lecture" test the mean score was 62.67. The "practical" mean was 6.42 points higher than the mean score for Group II and the lecture mean was 0.24 point higher. The differences in mean scores for Group I and II were not significant (see Table III).

It should be noted that there was a tendency for higher scores on the tests given after a period of instruction where labeled photomicrographs were supplied. Though none of the differences in means or variances were statistically significant, the difference was always in favor of the group receiving labeled photomicrographs. Moreover, the difference in "practical" scores was greater than the difference in "lecture" scores, as would be hypothesized since the photomicrographs were designed to aid in laboratory work. The data suggest that the use of labeled photomicrographs may be of value as a supplement to outline drawings in a laboratory guide. The question merits further study, though a longer period of time should be allowed during which only one group receives labeled photomicrographs.

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TABLE III

TEST FOR SIGNIFICANCE OF DIFFERENCE BETWEEN MEANS AND VARIANCES OF THE EXPERIMENTAL GROUPS AFTER INSTRUCTION IN BOTANY WITH OR WITHOUT SUPPLEMENTARY PHOTOMICROGRAPHS

Test	Group	N	Mean	Variance	F	t	Prob.
Practical	I	20	66.30	167.58			
Test II	II*	20	70.60	119.52	1.402	1.135	> .05
Lecture	I	21	59.76	104.20			
Test II	II*	21	61.52	166.95	1.602	.489	> .05
Practical	I*	20	63.37	206.37			
Test III	II	19	56.95	283.17	1.372	1.28	> .05
Lecture	I*	21	62.67	126.65			
Test III	II	21	62.43	129.35	1.021	.069	> .05
Practical	I*	19	49.89	240.22			
Final	II*	19	50.26	138.67	1.732	.083	> .05
Lecture	I*	19	52.00	135.56			
Final	II*	20	45.90	131.58	1.030	1.65	> .05

* Group received supplementary photomicrographs for four weeks preceding this test.

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AN APPROACH TO THE INTERPRETATION AND MEASUREMENT OF PROBLEM SOLVING ABILITY *

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Unlike lower animals, man is not born with a lifetime supply of behaviors which will allow him to cope with his environment. Man must *learn* behavior patterns which provide at least some measure of success with the problems at hand. In short, man must learn how to *solve problems.* To understand this process we must know how we learn and how we solve problems. In order to improve the methods by which we teach children how to solve problems, we must understand how we solve problems and how to measure or appraise changes in problem solving skill, if such changes occur.

The "connectionist" and the "gestalt" or "field theorist" groups of psychologists have described problems solving behavior [17]. Both groups have described learning as viewed under the theories and postulates of the psychologies. The teaching of problem solving has been discussed in the light of connectionism and gestalt psychology [3]. In spite of the fact that there has been much interest and discussion of the ability to solve problems, there seems to be little in the psychological literature prior to 1950 that would suggest a basis for constructing a course to enhance the students ability to solve problems. With respect to evaluation, even fewer ideas for test construction were suggested by the psychological literature.

An experiment was designed on the premise that to teach students to solve problems in science, we must require students to solve reasonably complex problems in science. The experiment was conducted by the writer with one group of students taught college general botany with the use of individual student projects and another group taught in a "conventional" manner with only lecture and laboratory work. The results of this study were presented elsewhere [19]. A survey of the available tests of ability to solve problems resulted in no tests suitable for this experiment. Therefore, it was necessary to construct a new test which would measure a change in ability to solve problems in science if such a change were to occur. Moreover, it was important that the test have validity and that the questions or problems would be such that the specific content of the test was not included in the general botany course.

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The procedure for the development of the test and results obtained in the study cited above are the basis for this paper.

PROBLEM SOLVING THEORY

The publication of *Cybernetics* by Wiener in 1948 [23] and Shannon's paper in 1948 [20] lead to a number of suggestions for the construction of computers which could solve problems. Both authors drew ideas from psychologists and the neurologists but the ideas applied to computers underwent necessary changes. In turn, the modified ideas have had implications for neurology and psychology. Wiener has suggested a variety of applications for ideas from cybernetics [24]. Since 1949, the developments in psychology with reference to information theory have increased markedly.

Miller [16] suggested that the probability that a given response will occur may change after a given event. This would mean that the event has supplied *information* which has resulted in the individual's conscious or subconscious reevaluation of the "success probability" of certain courses of action. Estes [7], Ashby [1, 2], McMillam [14], Miller [15], George [9] and Snider [22] are among the numerous authors who have utilized concepts from information theory to interpret operation of the mind. ·The emerging "cybernetic" interpretation of the mind has implications for the construction of mental tests and specifically for the construction of a test to measure problem solving ability.

One can view the mind as a complex storage unit and data processing device. [Cf. Snider, 22]. Whenever a problem is encountered, the information stored in the mind would suggest several possible courses of action which may be appropriate. The "success probability," i.e., the chance that a given course of action will lead to the solution of the problem, will be different for each course of action. The individual would normally select the course of action which has the highest success probability.

It is necessary to qualify the statement that the individual would choose the course of action with the highest probability of success by the word *normally*, since there may be information stored in the mind which was derived from emotional experiences which may have important influences on the selection of a given course of action. Though a given course of action may appear to have the best chance of success, the individual may select some alternative course of action if previous emotional learnings suggest that this is the "pleasant" course of action. It is possible that individuals may become conditioned to the selection of less appropriate courses of action due to the immediate emotional satisfactions derived from such actions in spite of the fact that these courses of action are less likely to bring success in the ultimate solution of a problem.

In addition to the effect of the emotional experience associated with the course of action selected, Galanter and Smith [8] report that individuals will use trial and error selection of answers to problems unless the chance of success is better with "recursive" or thought out answers. Guessing or random selection of courses of action is less likely to be effective if problems are complex. However, if the individual is repeatedly rewarded by "guessing" types of responses, since the problems presented to him are usually simple, he unconsciously develops an emotional set or *attitude* which favors the selection of courses of action by trial and error means. The measurement of emotional predisposition or attitude [Cf. Edwards, 6] is an area where much work is needed.

PROPOSED SCHEME FOR PROBLEM SOLVING ACTIVITY

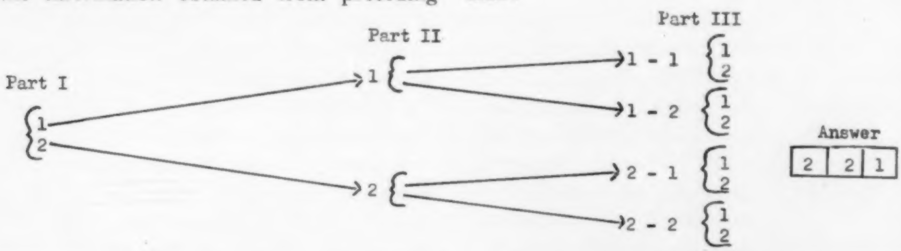
With the assumption that the individual with ability in problem solving can cor-

rectly assay the probabilities that certain courses of action are better than others, a test for problem solving ability should require the individual to select the most likely of several possible answers. This is what some of the problem solving tests or tests for "critical thinking" require [Cf. 5, 21]. Other writers have suggested tests where several successive "correct" choices are required [10, 13]. Seldom is a complex problem solved with the selection of a single behavior pattern. If we refer to the computer analogy of Wiener we find that a response, or some computational operation, provides information which is used in the selection of successive responses. As we solve problems, we utilize the information obtained from preceding attempts, though some attempts may have been only mental without any overt action, and with this information we unconsciously redefine the success probabilities of the remaining new courses of action. Through repeated selection of behaviors, each new selection modified with the information obtained from prior selections, we ultimately converge to the "correct" or successful course of action and the problem is solved.

DESCRIPTION OF THE TEST

Under the theory outlined above, a test for ability to solve problems should require the individual to select an "answer" which in turn provides him some information regarding the solution of the problem. He should then be required to select another "answer" which is based on or related to the previous answer. Thus the individual would repeatedly select the most probable correct "answer" until he arrived at or approached the solution of the problem.

A test was devised with six problems. To simplify the mechanics of the test, only two alternative courses of action or "answers" were provided at each step in the "solution" of the problem, and only three steps were given for each problem. The selection of a course of action would restrict future selection, though a student could go back and select a different alternative. Each problem could be diagramed thus:



In selecting responses, a student was restricted to any one course of action indicated by the arrows. For each step in the solution of the problem he had two possible choices. In a pilot administration of the test it was found that the best discrimination was obtained when an answer was counted wrong unless all three sections were correct. Thus if choice 2 were "correct" for the first part, choice 2 for the second part, and choice 1 for the third part, the answer would be given as 2–2–1. The procedure for solving the problems was illustrated to the students before the tests were administered. One of the problems is given below:

PROBLEM I *

Mr. K., a professor of physics, wondered if students would learn more if they were given instruction in how to read their physics textbook. He gave one group of his students ordinary lectures and the other group he gave regular lectures, but also some instruction on the best way to read their physics textbook. The first group was called the control and the second group, with instruction in reading, was called experimental.

* Based on a report by Kruglak [12].

first [1] answer

1. It is known that general ability is important to success in any course. If the students in the experimental class had higher general ability than those in the control class, we migh expect that they would receive higher final grades in physics than the control students.
2. Instruction in reading has been found to improve the reading comprehension of students in some cases. We should expect that instruction in reading the physics textbook would result in higher final grades for the students in the experimental class.

* * * * * * * * * * *

above answer [1|1] plus a second

1

1. Mr. K. studied the American Council on Education (ACE) exam scores for the students in the experimental and control groups. He found that the average scores were about equal. This was important for him to know in order that he could proceed to make comparisons of the experimental and control groups.
2. Mr. K. obtained the high school percentile ranks (HPR) for each of his students. He found that the students of the control and the experimental groups had about the same high school ranks, on the average. This suggests that no differences are to be found between the groups when the final grades are compared.

2

1. Many textbooks contain more information than is important. By giving instruction to the experimental group as to what material should be read most thoroughly, we could expect that Mr. K.'s experimental group would get higher final grades.
2. Many students taking science courses are poor readers. The experimental group should have a definite advantage over the control group, if they are taught how to read the textbook.

* * * * * * * * * * *

above answer [1|1|1] plus last choice

1–1

1. Mr. K. found that the students in the control group received about as good a grade on the final exam as did students in the experimental group. One should conclude that instruction in how to read a textbook does not improve a student's ability to do well in that course.
2. Mr. K. compared grades in the course for students in the experimental and control groups. Since the students did about equally well on the American Council on Education Exam when they were compared, we should not expect to find a difference in their course grades.

1–2

1. When Mr. K. made a statistical analysis of the differences between the grades received by the control group and the experimental group, he could not find any statistically significant differences. He should have expected this result, since the students in the two groups had about equal high school ranks.
2. The fact that Mr. K. could find no statistical difference between the control and the experimental group's grades illustrates the weakness of statistics. Perhaps he would have done better to ask his colleagues to study the two sets of grades and decide whether or not they appeared to be different, on the average.

2–1

1. Most science textbooks contain many scientific terms. Help in understanding these terms should have resulted in higher grades for the experimental group.
2. Physics textbooks often have many graphs and charts. If the instructor helped to interpret these, there is a good chance that the experimental group would get better grades than the control group.

2-2

1. Ability to concentrate on the material being read has been shown to result in higher reading comprehension. Students should be able to concentrate on their reading if they are given instruction in textbook reading, and consequently they should get higher grades.
2. There is some evidence that fast readers are also better readers. If the instructor points out how to best read a chapter, the students can read it faster and therefore better. This would be a good reason why students with instruction in textbook reading might get better grades than students without such instruction.

VALIDATION OF THE TEST

Most of the problems in the test were developed from published research reports. Consequently, the problems involved were real problems, though the answers were not such that the student would know what alternatives to select to reach the correct "answer." The test was given to fifteen scientists and graduate students at the University of Minnesota. The correct responses were taken as the answers these scientists gave to the problems. There was general agreement as to what the answers should be. This is shown in Table I and Figure 1. The scores given are the scores obtained when the tests were scored with the "most popular" answers given by the scientists.

In addition to the general agreement on the answers, the scientists remarked that the test did appear to test something which might be called ability to solve problems. They found the test interesting and suggested that it be used.

FIG. 1. Percentages Receiving Each Score on the Problem Solving Test Forms

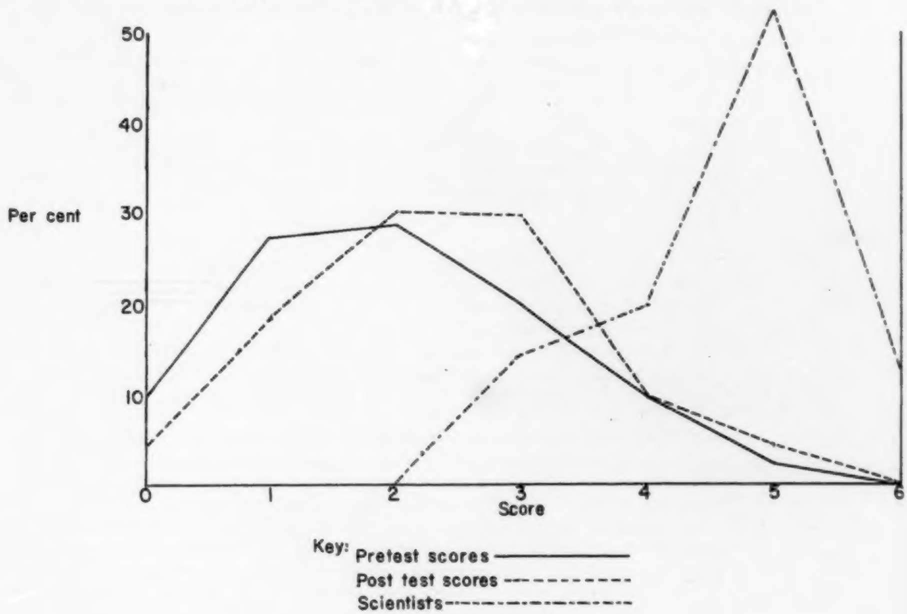


TABLE I

DISTRIBUTION OF SCORES FOR GENERAL BOTANY STUDENTS AND SCIENTISTS ON THE PROBLEM SOLVING TEST

Group		Score 0	1	2	3	4	5	6
Student Pre-test Scores	Number	33	83	87	60	31	8	0
	Per cent	10.9	27.5	28.8	20.2	10.3	2.6	0
Student Post-test Scores	Number	13	56	93	92	33	15	0
	Per cent	4.3	18.5	30.8	30.4	10.9	5.0	0
Scientists Scores	Number	0	0	0	2	3	8	2
	Per cent	0	0	0	13.3	20.0	53.3	13.3

Correlation coefficients between the problem solving test and the American Council on Education Psychological Examination (ACE test) was found to be low (r = .13). The correlation with a test for knowledge of botanical facts, given at the beginning of a course in botany, was also low (r = .11). It was concluded that the problem solving test may measure a different aptitude than was measured by the ACE test or the "botanical facts" test [19].

During the six-month experiment, in which the problem solving test used as a pre-test and a post test, gain in problem solving ability was found for both the "experimental" and "control" classes [19]. The gain made by the experimental group was greater, though not significant at the five per cent level, which suggested that the gain was not due entirely to practice but may be due to differential improvement in problem solving skill for students of the "experimental" and "control" classes. The data suggest that gain in problem solving ability can be measured with the test described in this paper.

RELIABILTY OF THE TEST

The test was given to 302 general botany students in the fall of 1956 and again at the end of winter quarter, 1957, at the University of Minnesota. The same pretests and post tests were used to obtain a measure of reliability with the method given by Jackson [11]. The value for e was found to be between .30 and .50 and was significantly different from zero at the 1.0 per cent level. The reliability of this test was lower than is desirable, especially if the test is to be used for individual prediction. However, there were only six problems in the test and it is likely that increasing the length of the test to fifteen or twenty problems would greatly increase the reliability, especially when poorer questions were revised or eliminated. The six problem test required approximately fifty minutes for administration and a twenty problem test would require about two hours.

ITEM DISCRIMINATION AND DIFFICULTY

The data from the post test were used to determine item discrimination and item difficulty as shown in figure 2 and figure 3, respectively. All of the items showed positive discrimination, though problem VI showed little discrimination between the high scoring students, i.e., those who got

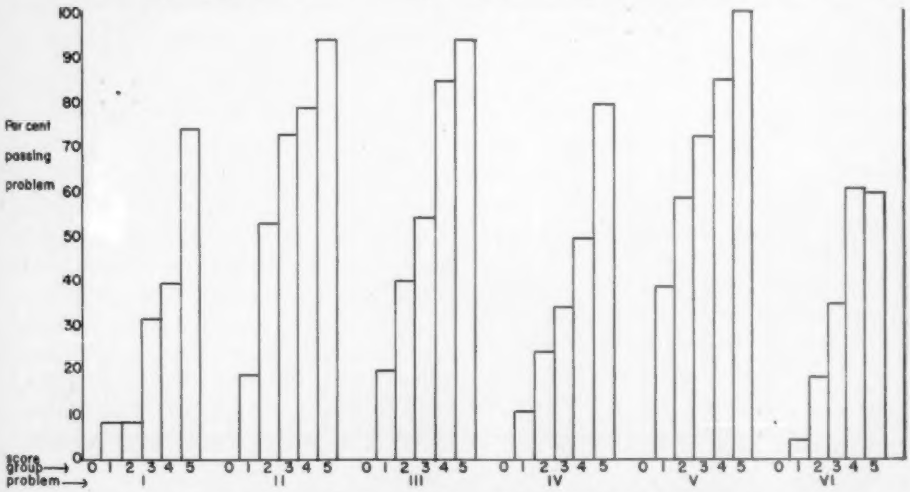


FIG. 2. Per Cent of Students in Each Score Group Passing Each of the Six Problems on the Problem Solving Test

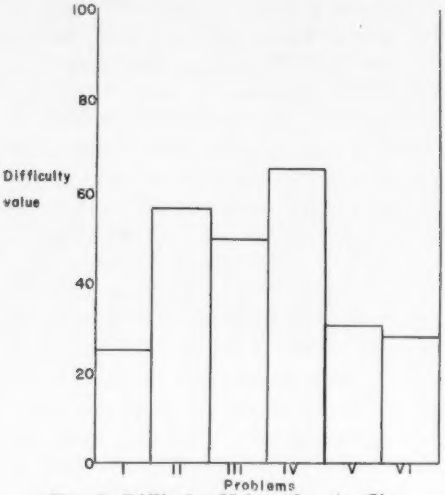


FIG. 3. Diffiiculty Values for the Six Problems of the Test

four or five of the problems correct. None of the 302 students got all six problems correct. In general, the items showed good discrimination. This suggests that a longer test with as good or better items would have reasonably good reliability.

Item difficulties were computed for each of the problems. Three of the problems had low difficulties (24, 28, and 32) and three problems were somewhat easier for the students in the study (difficulties of 49, 55, and 64). With the difficulty pattern obtained, the test was probably more discriminating at the higher than at the lower end of the ability range, though the data in figure 2 do not show this. If a test of this type were to be used for selecting the best "problem solvers," the difficulty pattern obtained may be satisfactory.

NATURE OF THE PROBLEM SOLVING PROCESS

If individuals proceeded in the solution of problems by random selection of answers, fifty per cent would make their first error at the first step of the problem (recall that each step had two alternatives). Twenty-five per cent (½ x ½) would make their first errors at the second step in the problem, and thirteen per cent (½ x ½ x ½) should have made their first errors in the third step of the problem. However, when the papers were checked, it was found that about eighty per cent of the students made their first errors at the first step of the problem. The first errors occurred with about equal frequency at the second and third steps of the problems.

Another question studied was the relative frequency with which the better "prob-

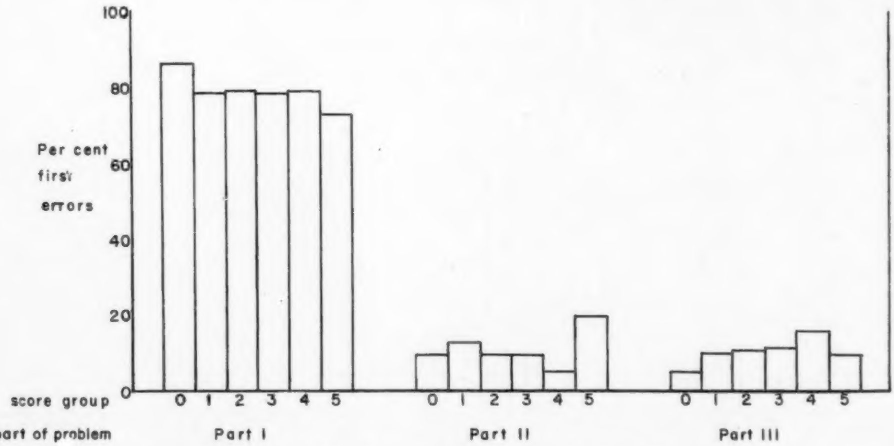


FIG. 4. Per Cent of "First" Errors Made on Each of the Three Parts of a Problem for Each of the Score Groups

lem solvers," i.e., those with higher scores, made errors at the three steps in the problems as compared with the frequency for the poorer "problem solvers." Figure 4 shows the per cent of first errors made at each of the three steps for the six score groups. Though there is some difference in the frequency of first-errors at step one for the high scoring as compared with the low scoring students, the differences were found not to be significant. The chi-square analysis give a chi-square value of 8.491 and with ten degrees of freedom, the value of P was between .50 and .70. This would mean that high scoring students are as likely to make their first errors at the first step of a problem as low scoring students. The data are summarized in Table II.

TABLE II

CHI-SQUARE ANALYSIS OF FIRST ERRORS ON THE PROBLEM SOLVING TEST BY PART OF PROBLEM AND SCORE GROUP

Score Group	Part I	Part II	Part III	Total
0	66	8	4	78
1	231	35	29	295
2	308	39	45	392
3	232	30	35	297
4	44	3	9	56
5	11	3	1	15
Totals	892	118	123	1133

$\chi^2 = 8.50$ With 10 df, $.50 < P < .70$

INTERPRETATION OF THE DATA

According to the theory of problem solving presented above, the individual with problem solving ability should successfully select the most appropriate course of action and successive courses of action should be selected with due consideration of the information or implications of previous courses of action. This would mean that a student with high problem solving ability would make fewer errors in successive selections of courses of action (answers in the second and third parts of the problem) than the student with lower problem solving ability. The data obtained do not support this interpretation and some explanation is necessary.

It should be pointed out that the failure of the error patterns to correspond to that expected under the theory given earlier may be due to the structure of the test problems. As they are presented, the successive choices may be relatively obvious if the subject selects the "correct" alternative at the first part of the problem. If this were true, we would expect most of the errors would occur at the first step of the problem. In checking through the comments of the validation group, it was found that several of the scientists felt that the alternatives at each step were very "close" and that frequently a final decision on the answer for the first part of a problem could not be determined with a satisfactory degree of certainty until all three parts were studied and the selections made. No member of the validation group commented that the answers to the second and third parts of the problems were obvious once the first selection was made.

With the above considerations, it remains possible that the good problem solver differs from the poor in that he more successfully considers the information of preceding behaviors (choices to parts one and two of the problem) in determining what is most likely the "correct" answer to the problem. The data available in this study do not show whether or not the good problem solver actually explores more possible "solutions" than the poor problem solver. It is possible that the individual with problem solving skill actually explores more possible answers, mentally or through overt behavior, and/or derives more information from each answer (behavior) he attempts. This question shall be studied in future investigations. A test format similar to that used by Glaser [10] could be used.

IMPLICATIONS OF THE STUDY

It is common practice in classrooms to provide questions or problems which re-

quire relatively simple and obvious answers. As noted earlier, it has been suggested that simple problems may encourage the development of behavior patterns and attitudes which may be detrimental in complex problem situations.

In the measurement of reading comprehension or problem solving ability, the usual procedure is to rank students according to the number of correct responses per unit of time. This method of scoring implies that the student who answers most questions correctly in a given unit of time is the student who comprehends best or solves problems best. This may be true, though the data in this study suggest that the student who ponders the possibilities of various solutions may be the student who is actually doing the best kind of problem solving, especially when the answers to the problem are not definite but only tentative.

If success in science depends on the solution of problems in such a way that many new problems come into clear focus, as suggested by Conant [4], we may have stressed the wrong performance in the teaching and evaluation of problem solving ability.

SUMMARY

Problem solving activity can be considered in the context of information theory. A theory of problem solving behavior based on an interpretation of the role of stored information and acquired information in selection of "courses of action" or behaviors has implications for the construction of a test to measure problem solving ability. Data obtained from administration of a problem solving test suggested that problem solving ability may be relatively distinct from ability to recall facts or principles. There is some evidence that problem solving ability can be improved.

The problem solving process may be explored through the use of a variety of tests which measure problem solving ability, provided the tests are valid. Data were presented which indicated that the first part of a complex problem is the place where most people select "incorrect" courses of action. This was found to be true for students who scored high on a problem solving test as well as for those who scored low. The data suggest further studies of the problem solving process.

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WHAT DO CHILDREN BELIEVE? *

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THE purpose of this study was: (1) to construct and evaluate an instrument for determining the prevalence of certain important general science misconceptions among ninth and tenth grade school children; and (2) to determine the prevalence of responses to the items of this instrument which suggest the occurrence of certain important general science misconceptions among ninth and tenth grade children.

The misconceptions to be used in the instrument were obtained from several sources including (1) previous studies of science misconceptions, (2) published books and articles pertaining to general science misconceptions and (3) the press, magazines, radio and television. In addition, approximately 900 high school pupils and their teachers were asked to cooperate by using the free writing technique. After being given examples of common misconceptions in order to establish clearly the types of unfounded belief to be used in the current study, the participating pupils and their teachers were asked to add unlimited numbers of misconceptions to the list submitted to them.

The 741 misconceptions which were compiled were screened by several science teachers to eliminate those items considered trivial, outdated, anti-social, without proof of truth or falsity, or having infrequent occurrence.

The remaining items were submitted to a college class in science education at Boston University to simplify and improve the readability and the structure of the items.

The revised and corrected lists of misconceptions then were submitted to three college professors who are specialists in science education. They were asked to delete all statements considered true and to evaluate each item according to the potentialities of the misconception for affecting the behavior of those who believed it to be true. They were asked to classify the unfounded beliefs, forming three groups; those having serious implication for the behavior of the individual, those having some implication for the behavior of the individual, and those having slight or no implication for the behavior of the individual.

* A paper presented at the Thirty-First Annual meeting of the National Association for Research in Science Teaching, Hotel Sherman, Chicago, Illinois, February 20, 1958.

Based on a doctoral dissertation entitled, "A Determination of the Prevalence of Certain Important General Science Misconceptions Among Ninth and Tenth Grade School Children, 1956," Boston University. Copies are on file in the library of the School of Education, Boston University, Boston, Mass. Microfilm copies may be purchased from University Microfilms, Ann Arbor, Michigan.

These corrected and evaluated lists of physical and biological misconceptions next were submitted, in a preliminary instrument, to a jury of secondary school teachers including ten general science teachers, five biology teachers, five physics teachers and five chemistry teachers. Each of these jury members was asked to rate every general science misconception according to its potentiality for affecting the behavior of the individual. If any statement was considered to be true, the rating was to be omitted and a line was to be drawn through the item. Instructions were given also to delete all statements pertaining to the supernatural or to mysticism.

When these inventories were returned, a frequency distribution was made of the jury responses to each statement. Then the total score of the frequency distribution of jury responses to each statement was determined. The general science misconceptions were arranged in the rank order of their decreasing importance on the basis of their total scores.

These preliminary screenings had reduced the original list of misconceptions to 193 physical science items and 252 biological science items. After the final screening of the items by all persons to whom they were submitted for evaluation, there were 78 physical science misconceptions and 117 biological science misconceptions which were to be used in the final instrument.

Using the results of the special evaluation instrument, the final inventory forms were constructed. In each form, approximately two thirds of the statements were false and one third of the statements was true. The true statements were added to the inventory forms so that the pupils would not discover that they were being examined for the prevalence of misconceptions. The true statements were taken from doctoral studies relating to science concepts and from current ninth grade text books. In addition, "sleeper" questions or stop items were used on each page of the inventory. The "sleeper" questions were simple false statements which were included to help identify those pupils who became frustrated in the scoring process and who then marked the score sheets without giving serious thought to the items. An example of a "sleeper" item would be: "A rabbit can talk." An examinee must answer two out of three of these "sleeper" items correctly in order that his inventory form be used to help determine the prevalence of science misconceptions among ninth and tenth grade pupils.

The final instrument consisted of five different inventory forms, each form having 60 items. Within each form there were 39 misconceptions, 18 true statements and three "sleeper" items. Items having serious potential for affecting the behavior of children and other items having some potential for the behavior of children were distributed equally within the inventory forms. Items that were high and also those that were low in rank order, as judged by the jury of 25 science teachers, were distributed equally within the forms. The biological and physical science items were distributed within the forms in a ratio of three to two. A pilot study was made in one junior high school for the purpose of comparing the inventory forms. This was done by determining the mean and standard deviation. The results showed that the forms were similar and could be used on a nation wide basis. The directions to teachers and the special I.B.M. answer sheets with directions for pupils were the same for all inventory forms.

The five inventory forms were distributed randomly and equitably among 3101 ninth and tenth grade boys and girls in selected parts of the United States. The examinees were allowed to respond to each item in a particular form in one of the following ways; true, sometimes true, false, don't know and don't understand. They

were instructed not to guess and were allowed as much time as they needed to complete the particular form they were using. Science classroom teachers were supplied with detailed directions pertaining to the administration of the inventory forms. This directive material was distributed by science supervisors and college professors who were participating in the study. All those taking part were either teachers of science or supervisors who were interested in better methods of teaching science. The forms were used in the ninth grade general science classes [1] and also in the tenth grade science classes.[2] They were administered by classroom teachers in regular classroom situations.

The answer sheets were machine scored to determine the number of misconceptions marked "false." The highest possible score on each form was 39. In this study only the "false" responses to the misconceptions were regarded as correct, although a pupil might have been justified in selecting the "don't know" or "don't understand" responses. The true statements or camouflage items were ignored in the scoring of the answer sheets. Of all the inventory forms returned, 2525 answer sheets were considered usable on the basis that all directions had been followed and all requirements had been met.

Graphic item counts of all responses to the statements were obtained for all the cases for each inventory form at each grade level. These frequencies were then converted into per cents for future tabulation and analysis to indicate the prevalence of certain science misconceptions among ninth and tenth grade school children.

An item analysis for each misconception in the five inventory forms used at the ninth grade level was made by using the Kirkpatrick and Cureton technique.[3] This technique is based on high and low criterion groups and provided tests of significance at three levels, 0.05, 0.01, and 0.001. It does not yield equal-unit scaling for discrimination.

The reliability coefficients of the inventory forms developed in this investigation were calculated by using the Walker formula.[4] The results suggest that the instrument has limited reliability as defined by Kelley.[5] In addition, the mean, standard deviation and the critical ratio of each inventory form at the ninth grade level were presented for boys and girls. The table, which follows, indicates the mean scores on the inventory forms, their stand-

[1] Montpelier High School, Montpelier, Vermont; Greensboro High School, Greensboro, Vermont; Johnson High School, Johnson, Vermont; Peoples' High School, Morrisville, Vermont; Hardwick Academy, Woodbury Vermont; Stowe High School, Stowe, Vermont; Spaulding High School, Barre, Vermont; Craftsbury Academy, Craftsbury, Vermont; South Junior High School, Quincy, Massachusetts; Central Junior High School, Quincy, Massachusetts; Quincy Point Junior High School, Quincy, Massachusetts; North Quincy High School, Quincy, Massachusetts; Aptos Junior High School, San Francisco, California; Horace Mann School, San Francisco, California; Presidio Junior High School, San Francisco, California; James Denman School, San Francisco, California; Columbia High School, Rensselaer, New York; Junior High School #157, Forest Hills, New York; University High School, Laramie, Wyoming; Gainesville High School, Gainesville, Florida.

[2] Western Hills High School, Cincinnati, Ohio; Central High School, Cincinnati, Ohio; Walnut Hills High School, Cincinnati, Ohio; Wenthrm High School, Cincinnati, Ohio; Withrow Senior High School, Cincinnati, Ohio; Robert A. Taft High School, Cincinnati, Ohio; Needham Broughton High School, Raleigh, North Carolina; Montpelier High School, Montpelier, Vermont; Keene High School, Keene, New Hampshire; North Quincy High School, Quincy, Massachusetts; Spaulding High School, Barre, Vermont; Stephen F. Austin High School, Austin, Texas.

[3] James J. Kirkpatrick and Edward E. Cureton, "Simplified Tables for Item Analysis," *Educational and Phychological Measurement* (Winter 1954), 14:709–714.

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ard deviations, and the critical ratio of the differences between the means of the boys and girls, together with the reliabilities of the inventory forms at the ninth grade level. The critical ratios were calculated by dividing the obtained mean difference by the standard error of the difference between the two means.

TABLE I

INVENTORY FORMS—GRADE 9

	Number of Cases		Mean Score		S.D.		C.R.	rtt	rtt
Form	(B)	(G)	(B)	(G)	(B)	(G)	(B) vs. (G)	(B)	(G)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
A	48	55	19.31	18.12	5.38	5.99	1.05	.811	.769
B	49	58	23.10	20.18	5.76	5.43	2.65	.813	.813
C	49	50	20.85	19.52	6.10	6.03	1.08	.824	.815
D	48	49	19.37	17.67	5.84	5.87	2.11	.814	.781
E	47	47	22.34	18.78	5.98	5.12	1.49	.813	.745

It has long been a matter of discussion among science teachers, based upon but little research, as to whether the beliefs of boys and girls were similar and of the same extent.

A major contribution of the current study is the inclusion of specific misconceptions and the responses of boys and girls in ninth and tenth grade classes to them, so that teachers may use items evidencing special difficulties or needs of children in their teaching.

Tetrachoric correlations were calculated for the I.Q.'s and the scores on each of the inventory forms. The following table shows the mean score, the mean intelligent quotient, the tetrachoric correlations between them computed by the Jenkins' technique,[6] together with the standard errors for all inventory forms at the ninth grade level.

The data indicate very low correlations between the I.Q.'s and the scores on the inventory forms at the ninth grade level, indicating almost no relationship between these two statistics. The results of the standard error of correlation indicate that the relationship between columns 8 and 9 and columns 10 and 11 was not worth investigating.

The results of this investigation, at the ninth grade level, are significant. For example, the per cent of ninth grade boys subscribing to certain physical science misconceptions having serious implication for the behavior of children ranges from 3 per cent to 75 per cent on selected items. Fifty

[6] W. L. Jenkins, "An Improved Method for Tetrachoric r," *Psychrometrika* (September, 1955), 3:253–258.

TABLE II

INVENTORY FORMS—GRADE 9

	Number of Cases		Mean Score		Mean I.Q.		Tet (I.Q.) vs. $r(M_t)$		σr	
Forms	(B)	(G)	(B)	(G)	(B)	(G)	(B)	(G)	(B)	(G)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
A	48	55	19.31	18.12	110.97	119.25	.194	.157	.138	.131
B	49	58	23.10	20.18	117.60	115.20	.303	.215	.129	.124
C	49	50	20.85	19.52	114.65	116.86	.234	.000	.135	.000
D	48	49	19.37	17.67	114.81	119.22	.342	.285	.142	.131
E	47	47	22.34	18.78	120.92	115.72	.126	.039	.140	.145

TABLE III

PHYSICAL SCIENCE MISCONCEPTIONS BELIEVED BY FIFTY PER CENT OR MORE OF NINTH GRADE BOYS

When tobacco smoke is blown through a handkerchief, the yellow mark produced is due to nicotine.
Gasoline burns in the liquid state.
Cream is heavier than milk.
Water always boils at the same temperature.
During the winter, it is colder near the ocean than it is away from the coast.
There is always a calm before a storm.
Water with minerals dissolved in it is dangerous to drink.
The almanac can predict the weather conditions each day for a whole year in advance.

per cent or more of the boys subscribe to the following physical science misconceptions having serious implication for the behavior of children.

The per cent of ninth grade girls subscribing to certain physical science misconceptions having serious implication for the behavior of children ranges from 2 per cent to 91 per cent on selected items. Fifty per cent or more of the girls subscribe to the following physical science misconceptions having serious implication for the behavior of children.

Another method of presenting the misconceptions discovered to be prevalent among high school pupils would be to group them according to the units of work studied in the classroom. This procedure

TABLE IV

PHYSICAL SCIENCE MISCONCEPTIONS BELIEVED BY FIFTY PER CENT OR MORE OF NINTH GRADE GIRLS

Cream is heavier than milk.
When smoke is blown through a handkerchief, the yellow mark produced is due to nicotine.
Gasoline burns in the liquid state.
Oil is heavier than water.
During the winter, it is colder near the ocean than it is away from the coast.
There is always a calm before a storm.
The almanac can predict the weather conditions each day for a whole year in advance.
A burn from boiling water is more severe than one from steam.
The needle of the compass points to the north geographic pole.
Water always boils at the same temperature.
North is always up, and south is always down.
Thunder comes before lightning.

would aid the teacher in clarifying many misunderstandings as the various units of work were taught. The units "Life on the Earth" and "Weather and Climate" for example, are discussed in many science texts. The physical and biological science misconceptions relating to these units and also having serious or some implication for the behavior of ninth and tenth grade children as judged by a jury of twenty-five science teachers and specialists are listed below. To indicate the prevalence, the percentages of all the boys and girls who believed these misconceptions are given. In this grouping, there are of course some duplications of the items believed by 50

TABLE V

PHYSICAL AND BIOLOGICAL MISCONCEPTIONS BELIEVED BY NINTH AND TENTH GRADE STUDENTS

Unit I. Life on the Earth—Animal and Insect Life

Boys			Girls	
9th Grade	10th Grade		9th Grade	10th Grade
84%	71%	A rattle-snake always warns before it strikes	67%	73%
55%	56%	A barking dog never bites	58%	52%
53%	42%	The larger the dog, the safer he is for children.	36%	43%
#*53%	55%	When a dog is fond of a man, it shows that person to be trustworthy.	62%	66%
*43%	35%	Some animals are as intelligent as the average man.	69%	45%

* Misconceptions more prevalent among girls than boys.
\# Misconceptions increasing in prevalence at tenth grade level.

Boys 9th Grade	Boys 10th Grade		Girls 9th Grade	Girls 10th Grade
*39%	20%	The bite of most spiders is poisonous.	46%	26%
*37%	36%	An adult moth eats wool.	47%	39%
*22%	15%	The flicking tongue of a snake does the stinging.	41%	39%
*66%	56%	The grasp of a large octopus is unbreakable by a strong man.	69%	58%
*61%	52%	All animals are born with the skills and knowledge to keep them alive.	73%	57%
60%	56%	If one does not scratch a mosquito bite, it will stop itching.	68%	46%
*56%	49%	Animals can see in complete darkness.	73%	65%
56%	44%	Bloodhounds will attack those they are hunting.	39%	45%
*55%	48%	Bulls are made angry by the sight of anything red.	65%	58%
#*46%	56%	A tapeworm eats so much of its victim's food that the victim is always hungry.	56%	67%
#*43%	43%	Snakes can be charmed by music.	45%	46%
*27%	13%	A bat will try to fly into a girl's hair.	38%	29%
		Human Life		
*78%	70%	Those who learn slowly retain more of what they learn than those who learn fast.	83%	76%
64%	64%	Those who threaten to commit suicide seldom do.	79%	56%
#*52%	52%	A drowning person who goes down for the third time is lost.	66%	70%
51%	48%	Whiskey calms the nerves.	60%	43%
45%	40%	A weak mind and a strong back go together.	35%	30%
*42%	38%	Cutting a man's hair often and short makes it grow thicker.	52%	55%
42%	41%	Intelligent children are not usually strong.	33%	34%
#41%	43%	Women are inferior to men in intelligence.	38%	44%
*41%	32%	Mental diseases cannot be cured	42%	41%
40%	38%	Brains and beauty rarely go together.	39%	36%
#38%	40%	If a drunken man falls, he never hurts himself.	37%	49%
#*37%	40%	Most men of genius do not enjoy vigorous health, nor do they live as long as the average.	38%	41%
#35%	37%	Brunettes are more trustworthy than blonds.	30%	36%
34%	34%	Throwing a person off a dock is an almost certain method of teaching him to swim.	31%	28%
32%	25%	Children who do very well on intelligence tests are usually peculiar.	23%	25%
*32%	31%	Bacteria are always harmful to man.	36%	35%
29%	29%	A person's character can be judged accurately by looking at his face.	40%	37%
*28%	23%	The drinking of water with one's meals prevents the proper digestion of food.	31%	33%
25%	33%	Whiskey is good for snake bite.	36%	32%
*82%	83%	Fat people are jolly people.	91%	90%
*64%	61%	Everyone has genius of a certain sort, the problem is to find out what it is.	79%	64%
59%	52%	Any physical or mental disease can be produced by thinking too much about it.	57%	57%
58%	49%	Children sometimes inherit characteristics from a previous wife of their father	53%	37%
*57%	66%	When a living thing dies, all the cells are dead.	71%	70%
56%	51%	A man falling from a great height will always be dead before he hits the ground.	54%	54%
#*50%	61%	Women with red hair are quick tempered.	65%	75%
#*44%	48%	Long slender hands are an indication of an artistic nature.	58%	63%
36%	29%	A heavy growth of hair on a person's chest and limbs indicates great physical strength.	33%	32%
35%	31%	The human race was descended from monkeys.	34%	31%
29%	29%	Finger prints can be changed by using acid.	32%	16%
*29%	38%	Women possess a power of intuition absent in men.	57%	47%

* Misconceptions more prevalent among girls than boys.
\# Misconceptions increasing in prevalence at tenth grade level.

Boys			Girls	
9th Grade	10th Grade		9th Grade	10th Grade
*17%	12%	The stomach is below the waist line.	69%	40%
#49%	54%	Frost kills disease germs.	36%	41%
#41%	41%	Snow kills germs.	20%	25%
49%	46%	If animals acquire an unusually heavy coat of fur, that fact foretells a severe winter.	42%	44%
42%	37%	The behavior of certain animals is more reliable in predicting the weather than is the U. S. Weather Bureau.	37%	35%
*42%	36%	Sea gulls circling in large numbers mean that stormy weather is coming.	55%	40%
*56%	45%	During the winter, it is colder near the ocean than it is away from the coast.	61%	57%
*53%	53%	There is always a calm before a storm.	61%	60%
*51%	42%	The almanac can predict the weather conditions each day for a whole year in advance.	57%	51%
[illegible]	38%	A rising barometer indicates stormy weather.	40%	46%
42%	22%	The sun moves from one point in the sky to another during the day.	36%	32%
#38%	40%	If it rains before seven o'clock it will clear before eleven o'clock.	30%	39%
*36%	38%	Sea water never freezes.	41%	39%
*35%	35%	Thunder comes before the lightning.	50%	42%
*32%	29%	Lightning will not strike an automobile.	34%	33%
70%	72%	Water always freezes when its temperature is reduced to 32 degrees Fahrenheit.	75%	65%
*63%	56%	Frost is formed usually on the outside of a window.	77%	68%
*62%	66%	If you can see many stars in the sky, we will have fair weather.	69%	68%
*61%	58%	The sun is the center of the whole universe.	63%	71%
57%	50%	It gets colder in direct proportion to the distance north of the equator.	54%	42%
*50%	53%	Artificial ice is different than natural ice.	75%	68%
*49%	32%	The air pressure inside the house is different than it is outside the house.	52%	50%
*48%	39%	Ice is heavier than water.	56%	43%
#*43%	45%	Ocean waves are sometimes mountain high.	49%	53%
*39%	37%	As one goes up in the air, the air pressure increases.	51%	58%
#37%	44%	A change in the moon is responsible for a change in the weather.	31%	36%
33%	27%	When we fan ourselves, we cool the air around us.	44%	27%

* Misconceptions more prevalent among girls than boys.
# Misconceptions increasing in prevalence at tenth grade level.

per cent or more of the ninth grade students.

The results of this study suggest that if a systematic analysis, by teachers and pupils, of these misconceptions was undertaken, the resulting gentle skepticisms of printed statements about the physical world might transfer to other untrue statements now believed to be true and not on this list, or to statements which they will read or hear in the future.

Now that the physical and biological misconceptions having potential for affecting the behavior of school children were identified, they might be used as a partial basis for the selection and organization of subject matter and interactions in the fields of physical and biological science.

RESPONSIBILITIES OF THOSE PARTICIPATING IN THE TRAINING OF SECONDARY SCHOOL SCIENCE TEACHERS IN THE PACIFIC NORTHWEST *

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Recent developments in the scientific fields have served to emphasize the role of the secondary science teacher. His students, the public, persons in industry and leaders of national organizations are asking more of him than perhaps ever before in history. The science student in college who plans to teach must become prepared in the best manner possible to meet the challenge. To help him, the persons concerned with his preparation are faced with several responsibilities.

Out in the Northwest, in the states of Oregon and Washington, there are numerous small towns and rural communities with fewer than two or three thousand people. The science teacher in the secondary school serving one of these communities may be the sole science teacher, or if several are present, each probably has one or more non-science preparations. These types of teaching assignments are the ones for which Northwest colleges and universities must prepare the majority of science teachers.

The teaching assignments just described are undoubtedly common wherever population distributions are similar, and the responsibilities to be cited probably have their application in other geographical regions. However, my knowledge of the preparation of science teachers is limited largely to the region under discussion and is based upon research, observations made as a secondary science teacher and critic for student teachers, and experiences as an instructor in secondary science education.

With regard to the research, the investigation dealt with instructional problems of beginning secondary school science teachers in the Pacific Northwest. Twenty-five interviews were conducted initially with beginning teachers in fourteen districts in order to determine the types of instructional problems. The data were incorporated in a comprehensive sixteen-page questionnaire. The 130 beginning science teachers who responded were teaching in 108 schools in ninety-five districts in Oregon and Washington. The findings have been published previously.

Authorities have proposed in the past twenty-five or thirty years a broad training for teachers entering the secondary science field. The suggestions of these authorities have gone unheeded in many places as students were expected frequently to complete a major and/or minor in a specific science to meet graduation requirements. More recently there has been a change in emphasis with some writers proposing specialization, particularly in the fields of physics and chemistry. The undergraduate is faced with two choices: specialization or completion of a broad training.

But what of the specialist who begins his teaching career in one of the large number of small secondary schools in the Northwest? The investigation mentioned showed that the respondents had few opportunities to teach any particular science exclusively. Most of them had been required to teach aspects of the biological, physical, and/or earth sciences within the first four years of their teaching experi-

* A paper presented at the Thirty-Second Annual Meeting of the National Association for Research in Science Teaching, Hotel Dennis, Atlantic City, New Jersey, February 18, 1959. This paper is based on findings in the author's dissertation for the degree of Doctor of Education, University of Washington, 1957.

ence. Furthermore, at the time of the survey, almost one-half of them had not taught or were not teaching the science in which they had specialized.

These statements lead to the recognition of the first area of responsibility for those concerned with teacher training: the determination of a realistic preparation in subject-matter for the prospective science teacher. To attain this goal at least three things must be done. First, a continual survey of the prospective teaching assignments should be made by the county and district superintendents and the information forwarded to the colleges and universities. The teaching assignments should be projected one or two years in the future. Second, survey results must be made available to and used by faculty advisors and students so that college programs can be planned with objective information. Third, graduation and teacher accreditation requirements have to be reviewed. With regard to this point, in the State of Washington, a general certificate is issued on a temporary basis when the student is granted a bachelor's degree in education and on a permanent basis after at least one year of teaching and a fifth year of study. It is possible, by careful planning, for the undergraduate to complete eighty-eight quarter hours of credits in science and mathematics and still complete other required work. It is this writer's suggestion that the eighty-eight credits include fifteen credits in botany, five in geology, fifteen in zoology, five in physiology, fifteen in chemistry, fifteen in physics, five in astronomy and meteorology, ten in mathematics and three in science education. After completing this program the student should be prepared, from the standpoint of subject-matter, to teach general science, biology, physics, and chemistry with a fair degree of proficiency. With regard to such broad training, it is granted that if the teacher were assigned to teach only one of these sciences and were to continue to do so for a number of years, the preparation would be inadequate. Such a teaching assignment, however, is the exception rather than the rule.

Subject-matter training alone will not suffice to prepare a science teacher in the Northwest any more than elsewhere in the country. In the smaller communities he probably will be required to determine the scope and sequence for several science courses without the assistance of a supervisor, department head, or curriculum consultant. Unless he has had definite training in organizing courses he will have a tendency to rely on that which he has been taught or the textbook he inherits. Although these tendencies are not necessarily as evil as they have been made to seem, they can lead to a stereotyped course. However, the undergraduate must gain more than proficiency in listing concepts, generalizations, learning experiences and objectives for teaching units. Such preparation is helpful but does not comprise sufficient training for the prospective teacher who must later organize, continually modify, and improve science courses. Prior to graduation, he should be given the opportunity on several occasions to consider a variety of factors in course and lesson planning. Some of these factors are associated with science teaching in many of our Northwest schools.

1. A broad range in ability of students, including the slow and superior pupil.
2. The teaching of science in non-science classrooms with outmoded and inadequate numbers of texts, supplementary books and references.
3. The problem of devising useful laboratory work and demonstrations for use in classrooms with inadequate numbers of gas outlets, hoods, microscopes, electrical outlets, and demonstration and laboratory tables.
4. The prospect of changing rooms to teach science classes.
5. The great variations in interests and past performances of college and non-college preparatory students.

Now it is hardly conceivable that the new teacher will be able to plan effectively in detail one or more science courses his

first year. It seems likely though, that unless he has been given the opportunity to practice the process, and is aware of these and other teaching problems, his first year of science teaching may be an unsatisfactory experience. In addition, the foregoing planning procedures should enable him to cope in a better manner with multiple preparations. Almost half of the 130 teachers mentioned previously had three preparations each day; and many four or more.

To give the undergraduate assistance in planning is only the second responsibility. The third lies in the realm of methods of teaching. Beginning science teachers indicated that they frequently had difficulty with various instructional techniques. The most common problems had reference to providing modified work for slow and superior pupils, devising and using individual projects, taking science field trips, using teacher-pupil planning, and providing suitable demonstrations and laboratory work.

The partial resolution of these problems lies with college personnel. However, in a general methods course the instructor has few opportunities to establish relationships between methods and particular subjects, and although the student teaching experience is very valuable, attention to numerous important techniques may be lacking. Yet, if the beginning science teacher attempts to vary his teaching procedure by introducing techniques commonly associated with science teaching and does so unsuccessfully, he may make no further move in this direction.

The instructors of general methods courses should permit the science students to study and work with methods as they pertain to science. If this is not possible, then the undergraduate should be allowed to complete his methods requirements in a science methods course, or take additional work in science education to supplement his knowledge of science teaching procedures. Whatever course of action is chosen, the student ought to have the opportunity of practicing, discussing, and observing techniques as they pertain specifically to science classes. He should prepare and present demonstrations and laboratory work to class members, become acquainted with science projects of common interest to secondary students, participate in the planning and completion of science field trips, know activities and subject-matter which will be satisfying to the slow learner, and develop special projects and work which will challenge the superior pupils.

In the area of evaluation lie two responsibilities, perhaps two of the most important. The first has reference to self-evaluation by the teacher. All of us here are aware of a common interest of teachers, namely, the reasons for classroom difficulties. The beginning science teachers who cooperated in the aforementioned survey also indicated a moderate to deep concern about a number of problems that were stated in terms of the pupils. More than forty per cent of the respondents thought that pupils lacked ability to understand demonstrations, did not read science material easily, failed to accomplish a minimum of work if they were slow learners, did not have enough to do if they were superior pupils, were neglectful of equipment or used it improperly, were inadequately prepared to cope with science work, were not willing to do home work, showed a reluctance to complete assignments and to bring materials and specimens to class, and often were unable to follow directions in laboratory.

The concern of these teachers about pupil behavior amply indicates a common oversight of teachers. This oversight is the failure to examine in an objective and critical manner our own instruction. The beginning science teachers were blaming the students for many acts that may well have been largely the fault of the instructors. This is not to say that all behavior problems are caused by teachers,

but that many problems do result from teacher neglect. For example, it may be true that students entering a science class in the fall of the year are unable to cope with the work and that their preparation has been inadequate, or that the students do not understand demonstrations; however, these situations should not remain problems if the teacher realizes that adjustments must be made. The idealistic newcomer in the teaching field will have a rude and perhaps unpleasant awakening when he views the reality of the classroom. His college instructors do him a dis-service if they permit him to believe that all students in secondary schools are going to respond with willingness, interest, and understanding whenever he speaks. The student in college should be given definite and self-observable criteria upon which he can rate his own teaching, whether it be presenting a demonstration, assigning a lesson, supervising a laboratory period, or assisting students while they study. In addition, the student should be given the opportunity to rate himself and compare his opinions with those of his peers and instructors.

The second aspect of evaluation needing attention lies in the classroom of the science teacher. Grade prediction studies begun at the University of Washington and now expanding to other schools in the Northwest have shown a continued lack of significant correlation between marks earned in high school science and success of students in college science classes. (The same lack of significant correlation exists between other high school courses and related subject-matter areas at the University of Washington.) These facts serve to emphasize that college teachers who are responsible for tests and measurements courses must impress upon the prospective science teachers, among others, the importance of continuing to improve evaluation techniques. The beginning science instructor, with many new problems, does not have time to determine the validity and reliability of each quiz or examination. However, he should be provided with the information regarding the sources and usage of recognized examinations that have been standardized with students of *comparable ability and educational background.* In addition, the teacher should make continued effort toward establishing a true relationship between the grade the student receives and his general ability and achievement in the study of science.

Before we leave the college instructors and their responsibilities, another major aspect of teaching science should be discussed and several areas of lesser significance ought to be mentioned. The major area pertains to equipment and materials. Previously, the point was made that in many science classrooms there was a marked deficiency of items customarily considered necessary and significant for science instruction. Some beginning science teachers will have one of two choices: either to teach with the equipment at hand and supplement or improvise as the occasion demands, or be responsible for ordering equipment as funds are made available. The personnel at the colleges should prepare the students for either of these eventualities.

Even though the secondary science teacher does not have the fine equipment with which he worked in college, the absence of it should not serve to discourage him provided he has been forewarned. Many suitable laboratory experiences and demonstrations can be given to him, prior to teaching, that can be completed without the usual tools and materials. Most communities have a wealth of material suitable for classroom usage. In addition, in the Northwest region is to be found a variety of areas in which specimens of many types can be secured with no cost except for transportation. Within each of the two states are six life zones as well as the ocean, sounds, rivers, and lakes.

But suppose funds are available. The multitude of science catalogues pose a prob-

lem to the science teacher who is unacquainted with values and necessities. He should know, before he graduates, the types of equipment and material considered satisfactory and desirable for secondary students. The relative values of quantity versus variety should have been discussed. He should realize that there is always another year and that ordering expensive materials in quantity without first knowing their usefulness in secondary classes can result in waste. Personnel in college have the responsibility of informing prospective teachers of the sources of equipment and techniques for ordering, the importance of a continuous inventory and replacement procedure, and that the wise use of public money is mandatory.

The several minor aspects of science teaching about which the undergraduate needs some instruction include science clubs, science fairs, and science assemblies and their relative values. It is quite probable that during the early years of his teaching career the science teacher will be asked to supervise one or more of these activities. In his first year he should avoid initiating or directing these types of activities and should concentrate on improving his classroom teaching. If this course of action is not possible, he ought to know of the procedures and techniques necessary for organizing and directing the activities so that the duties can be completed with reasonable success.

After graduation the training process continues, as preparation does not end with the granting of a diploma or certificate. Now the administrators and particularly the secondary school principals must employ several measures to help insure a successful effort on the part of the new science teacher. In general the procedure can be separated into two categories, initial and continuous.

Orientation of new teachers is a common technique but is often incomplete. More than fifty per cent of the instructors who cooperated in the previously mentioned survey indicated they had not been informed about responsibilities regarding safety and liability in the laboratory, science subject-matter presented in other grade levels or classes, community resources, community attitudes towards science teaching, library resources, and coordination of the sciences the teacher was to teach with other sciences taught in the building or district.

Orientation is only one initial procedure. Principals should make a concentrated effort to avoid the practice of requiring the new science teacher to make more preparations each day than the experienced teacher. The first year teachers responding in the survey indicated an average of more than three daily preparations while the fourth year teachers averaged almost one less. The assumption seems logical that the established teacher takes the preferred assignments and leaves the rest to the untried person. This is a paradox wherein the presumably more experienced and better qualified person is paid a higher salary for making a lesser effort. In addition, the new instructor often changes rooms to teach science while the older teacher retains a constant teaching location.

Related to scheduling is the matter of class size. In the Northwest, as in other schools, there is the need for constant increases in funds to offset increasing enrollments. Although twenty-five is considered an optimum number of pupils in a laboratory class, the administrators apparently believe they are compelled as an economy technique, to increase the pupil-teacher ratios. Many biology and general science classes have more than thirty pupils. Here again, the new science teacher needs assistance. He ought to be assigned classes of a size that can be taught well under laboratory conditions if he is to gain experience, knowledge, and understanding of the techniques and methods customarily associated with science teaching. Although the absence of funds may be considered an excuse for large classes, the fact

remains that small classes can be retained by excluding students until more funds and teachers are available.

Throughout the year the principal has several additional responsibilities. He ought to observe the beginning science teacher repeatedly, offer constructive suggestions, and permit the teacher, in turn, to observe experienced and expert teachers of science. He should encourage purchasing of equipment. He should require the new science teacher to prepare course outlines for use by necessary substitutes and to aid in pre-planning the subsequent science program. He should encourage the new science teacher to return to school during the summer or complete additional work by extension or correspondence. Also, the new instructor ought to be provided with a place and time to make preparation. With regard to this latter point, sixty per cent of the beginning science teachers indicated in the survey they either did not have a preparation period or were unable to use their science room for preparing.

In closing, several remarks are in order. First, we in the Northwest have much room for improvement in the training of secondary school science teachers. However, these remarks have not been meant to imply that the teaching of science in our schools is necessarily poor or good. Research with regard to achievement and activities in the classrooms needs to be conducted. It is evident, however, that a continuous effort to improve the instructional ability of our secondary school science teachers must be made. It is not an impossible task and in reality is a most challenging and stimulating prospect.

AN INVESTIGATION OF INSTRUCTION PROBLEMS ENCOUNTERED BY BEGINNING SECONDARY SCHOOL SCIENCE TEACHERS IN THE PACIFIC NORTHWEST *

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PROGRESS in the development of science brought ever-expanding demands on the science teacher in public schools of the twentieth century. Requirements of accrediting organizations, colleges, universities, and secondary schools, and the wide range of interests and abilities of pupils found in science classrooms made the role of the science teacher increasingly important.

Classroom teaching by the author and work as a critic teacher, combined with discussions of professional problems with other science teachers, showed that beginning secondary school science teachers had difficulty with a variety of instructional problems. As long as these problems remained unsolved, teachers could not do their best work, nor could the pupils and community gain the benefits they should from the science program. It appeared logical, if these instructional problems were of sufficient import, of a concrete nature, and common among beginning science teachers, that they be identified and their solutions explored.

The study was limited to those science teachers who had been teaching four years or less. The problems investigated were those associated with pre-service training, teaching assignments, pupil-teacher ratios, physical facilities, audio-visual equipment and materials, instructional materials, evi-

* A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education, University of Washington, 1957.

dence of administrative interest and assistance, teaching methods and techniques, pupil attitudes, and teacher attitudes.

Interviews were conducted with twenty-five teachers in fourteen districts of eastern and western Washington. The interviews served to identify the types of problems the teachers were facing. The data procured from the interviews were used in formulating a questionnaire which was sent to 292 teachers in Oregon and Washington. One hundred ninety questionnaires were returned, but sixty were not usable because the teachers had been teaching more than four years. Of the 130 respondents, sixty-six were teaching general science, sixty-three were teaching biology, twenty-seven were teaching physics, and thirty-one were teaching chemistry. Forty-three were first-year teachers, and twenty-nine each had taught two, three or four years.

All of the respondents had completed a bachelor's degree and twenty had earned a master's degree. Sixty-nine had received a bachelor's and/or a master's degree in science. Only nineteen had not completed a major and/or a minor in science. An analysis was made for the credits earned in science by utilizing the recommendations given in the Forty-Sixth Yearbook of the National Society for the Study of Education. Very few of the general science teachers had completed work in the earth sciences, and only twelve had earned twenty-seven or more credits in both the biological and physical science areas. One-half or less of the biology, physics, and chemistry teachers had earned twenty-seven credits in each science they were teaching. In spite of the limited pre-service science training, eighty teachers thought that their pre-service training had been adequate, and three-fourths of them thought that they were doing an effective job of teaching science.

Eighty-five of the one hundred thirty teachers had taught general science, seventy-eight had taught biology, forty-one had taught physics, and forty-six had taught chemistry. One hundred twenty-two had taught either biology or general science, one hundred ten had taught general science and/or one of the physical sciences, and thirty-seven had taught biology and at least one of the physical sciences. Eight teachers had taught only physics and/or chemistry, and five of these teachers had taught only one or two years.

The number of daily preparations caused problems to quite a few teachers. Seven of the twenty-six teachers in junior high schools had three or more each day, nine of the twelve teachers in high schools of less than one hundred enrollment had four or more, and thirty-three of the thirty-four teaching in high schools of one hundred to three hundred enrollment had three or more preparations. In high schools of over three hundred enrollment, only eight had more than two daily preparations. From the standpoint of years of experience, the average number of preparations were as follows: first-year teachers, 3.07; second-year teachers, 2.71; third-year teachers, 2.76; and fourth-year teachers, 2.35. The range was not great, but showed that the first-year teachers had an average of almost one additional preparation each day compared to fourth-year teachers. Seventy per cent of the first-year teachers had three or more preparations, while twenty-four per cent of the fourth-year teachers had that many. Coupled with the number of preparations was the lack of space and/or time in which to prepare. Seventy-two per cent of the teachers either did not have a preparation period, or if they did, were not able to use the science room.

Class size was often mentioned in educational literature, with recommendations on the optimum number of pupils that should be in class.

A few beginning science teachers failed to indicate the number of pupils in each class. However, the teachers that did report, indicated that they were teaching nine thousand eighty-seven pupils in three

hundred sixty science classes. This was an average of 25.07 pupils per teacher which appeared to be a satisfactory ratio until the classes were subdivided by type of science class and school.

Seventy-eight, or sixty-eight per cent, of the one hundred fifteen general science classes had more than twenty-five pupils in each class, with the average number over thirty in junior high schools and high schools of more than three hundred enrollment. One hundred nine, or sixty-eight per cent, of the one hundred fifty-eight biology classes had more than twenty-five pupils. The average number of pupils in biology classes in high schools of more than three hundred enrollment was 28.07. Physics and chemistry classes averaged about optimum size; only nine of the thirty-nine physics classes and seven of the forty-eight chemistry classes were over twenty-five in size.

The lack of audio-visual equipment and materials presented problems to many of the respondents. Sixty-six of the one hundred thirty teachers did not have science classrooms equipped for using audio-visual aids. Thirty-five of the sixty-six did have the use of a special visual education room, but sixteen of the thirty-five teachers stated that problems still resulted. Fifty-three teachers noted that they did not have access to suitable films for science teaching and fifty-two indicated a lack of filmstrips and slides. Between one-third and one-half of these teachers stated that the lack of films and filmstrips caused instructional difficulties.

Sixteen of the questions in the questionnaire pertained to administrative interest and assistance. The areas in which the teachers most frequently noted deficiencies with respect to administrative assistance pertained to safety and liability in the laboratory, science subject matter being presented in other grade levels or classes, community resources, community attitudes towards science teaching, the philosophy of the school in relation to science, library resources, coordinating science teaching, free and inexpensive materials, courses of study, and resource units.

An additional sixteen questions pertained to pupils. These questions had a triple purpose. First, they aided in determining the problems teachers were having with pupils; second, they indicated the weaknesses of the teachers; and third, they helped in finding out if this group of teachers was composed of malcontents. Only a few teachers marked a majority of the problems with pupils as being of severe concern to them. The principal problems with pupils were related to reading science material easily, slow pupils not accomplishing an acceptable amount of work, superior pupils not having enough to do, unwillingness of pupils to do homework, neglect of equipment, bringing materials and specimens to class, reluctance to complete assignments, ability to understand demonstrations, general behavior, understanding relationships between laboratory and regular class work, and understanding diagrams and sketches.

Questions about physical facilities for teaching science were subdivided for each of the four sciences. The primary problems of general science teachers resulted from rooms inadequately equipped for teaching that science, rooms improperly arranged to permit free movement of pupils, inadequate storage space, and lack of microscopes, sinks, electrical outlets, gas outlets, laboratory tables, and demonstration tables. The same general problems were noted by the biology teachers with a greater emphasis on the lack of microscopes. Only twelve teachers had more than twelve microscopes in the classroom. The physical science teachers were not plagued with so many deficiencies in physical facilities. A major problem of the physics teachers referred to converting electrical energy to desired amounts and voltages, and the most serious problem of the chemistry teachers related to the absence of hoods.

Nine items in the questionnaire dealt with instructional materials. These were also subdivided for the four sciences. General science teachers found their difficulties stemmed most frequently from lack of adequate texts, supplementary texts, reference books, laboratory equipment, demonstration equipment, and charts. Biology teachers indicated similar deficiencies. On the other hand physical science teachers were not troubled by so many problems. About twenty per cent noted that lack of supplementary texts, reference books, demonstration materials, laboratory equipment, and charts caused difficulties.

General science and biology teachers emphasized problems arising from teaching methods and techniques. For all of the teachers, including the physical science instructors, the principal problems pertained to teacher-pupil planning, providing modified work for slow and superior learners, devising and using individual and class projects, planning and using demonstrations and laboratory work, and taking field trips.

The accompanying tables illustrated the manner in which the data were recorded. Tables on which related data were recorded for the other sciences were omitted from this presentation because they were too extensive.

Numerous recommendations were made by the teachers for solving the problems. These ranged from consolidating school districts and remodeling science rooms to providing opportunities for observing other science teachers and for graduate work in science teaching methods and curriculum. Some of the suggestions that pertained to school administrators referred to an orientation program which would include some emphasis on science teaching; initiating science curriculum courses in the county or district; call for the preparation of outlines by science teachers; limit a teacher's duty to teach only those sciences in which he was adequately prepared; and which would establish a science budget to expend certain determined amounts annually.

The accompanying table indicated the manner in which the teachers of general science made recommendations pertaining to the solution of problems related to teaching methods and techniques. In other portions of the questionnaire the respondents also checked suggested solutions or wrote their own suggestions which were catalogued and reported.

The findings also indicate that the beginning science teacher could do much to improve his teaching. Some recommendations were to explore, prior to the opening of school, the facilities available for teaching science; to work with pupils as individuals; to acquaint pupils with the purposes of science education, the areas to be studied and the procedures to be followed;

TABLE I

NUMBER OF BEGINNING BIOLOGY, PHYSICS AND CHEMISTRY TEACHERS GROUPED BY NUMBER OF EARNED QUARTER-CREDIT HOURS

Number of Credits	Number of Biology Teachers Who Earned Credits in Biology	Number of Physics Teachers Who Earned Credits in Physics	Number of Chemistry Teachers Who Earned Credits in Chemistry
45 or more	27	2	9
36 to 44	6	1	3
27 to 35	5	2	4
18 to 26	9	8	7
9 to 17	10	12	8
5 to 8	4	1	0
Insufficient data	2	1	0
	63	27	31

TABLE II

Yearly Teaching Experience of Beginning Science Teachers Grouped in Relation to Science(s) Taught

Sciences Taught	Years of Experience 1	2	3	4	Total
General science	13	8	4	7	32
Biology	8	7	2	3	20
Physics	1	0	0	2	3
Chemistry	1	0	1	0	2
General science and biology	6	2	7	6	21
General science and physics	1	0	2	0	3
General science and chemistry	2	1	0	1	4
General science, biology, physics	1	0	2	1	4
General science, biology, chemistry	0	2	1	0	3
General science, physics, chemistry	2	2	1	0	5
Biology, physics	0	0	1	0	1
Biology, chemistry	5	2	0	0	7
Biology, physics, chemistry	1	3	2	3	9
Physics, chemistry	2	1	0	0	3
General science, biology, physics, chemistry	0	1	6	6	13
	43	29	29	29	130

to write to colleges, universities and administrators of other districts for copies of courses of study and resource units; and to become acquainted with other science teachers and derive ideas and assistance from them.

It was apparent, as well, that secondary school science teachers need a broad training in science, for most of the teachers taught the all encompassing general science and/or biology. To specialize did not seem advisable. Recommendations were made regarding the science courses which a prospective science teacher should complete and the areas which a science methods course should emphasize.

TABLE III

Number of Daily Class Preparations of Beginning Science Teachers Grouped by Years of Experience

Number of Daily Preparations for Different Subjects or Levels	Years of Experience 1	2	3	4	Total
6	3	0	0	0	3
5	3	3	3	3	12
4	12	3	5	2	22
3	7	9	7	2	25
2	8	7	10	13	38
1	8	4	4	6	22
Insufficient data	2	3	0	3	8
	43	29	29	29	130

TABLE IV

Number and Size of Science Classes Taught by Beginning Science Teachers Grouped by Academic Level and School Size

	Junior High School	High School Less Than 100	High School 100 to 300	High School More Than 300
General Science Classes				
Number of classes	44	10	15	46
Number of pupils—total	1376	136	341	1418
Range in class size	15–40	4–22	7–37	12–38
Average number of pupils	31.27	13.6	22.66	30.83
Number of classes over 25	39	0	6	33

Biology Classes				
Number of classes	0	9	35	114
Number of pupils—total	0	125	773	3260
Range in class size	0–0	6–25	12–43	15–43
Average number of pupils	0	13.9	22.08	28.07
Number of classes over 25	0	0	16	93
Physics Classes				
Number of classes	—	4	13	22
Number of pupils—total	—	36	230	498
Range in class size	—	4–17	7–30	13–34
Average number of pupils	—	9	12.70	22.63
Number of classes over 25	—	0	4	5
Chemistry Classes				
Number of classes	—	4	20	24
Number of pupils—total	—	40	345	509
Range in class size	—	8–16	10–30	9–30
Average number of pupils	—	10	17.25	21.2
Number of classes over 25	—	0	2	5

TABLE V

NUMBER OF BEGINNING SCIENCE TEACHERS FROM WASHINGTON AND OREGON REPORTING UPON INSTRUCTIONAL PROBLEMS RELATED TO THE UTILIZATION AND AVAILABILITY OF AUDIO-VISUAL EQUIPMENT AND MATERIALS

		Responses of Teachers		Responses of Teachers When Asked if the Deficiency Caused Problems	
Questions Asked		Yes	No	Yes	No
Is each room in which you teach science suitably equipped to use audio-visual materials?	*W	44	46	35	11
	†O	20	20	12	8
If your room is not equipped to use audio-visual materials, do you have the use of a special visual room or another room when you need it?	W	25	21	14	7
	O	10	10	3	7
Do you have use of suitable science films for each science you are teaching when you need them?	W	57	33	15	18
	O	20	20	12	8
Do you have use of suitable filmstrips and slides for each science you are teaching when you need them?	W	56	34	10	24
	O	22	18	8	10
Which of these items are usually available when you need them?					
Film projector	W	86	4	3	1
	O	39	1	1	0
Opaque projector	W	39	51	23	28
	O	24	16	4	12
Micro-projector	W	27	63	20	43
	O	13	27	5	22
Bio-scope	W	9	81	6	75
	O	7	33	3	30
Film strip and/or slide projector	W	83	7	4	3
	O	35	5	1	4

* Washington science teachers.
† Oregon science teachers.

TABLE VI

NUMBER OF BEGINNING SCIENCE TEACHERS IN WASHINGTON AND OREGON REPORTING UPON INSTRUCTIONAL PROBLEMS RELATED TO PUPIL ABILITY AND ATTITUDES

Problems Included		Response of Teachers: Quite Severe	Moderate Concern	No Particular Problem
Pupils are reluctant to complete assignments	*W	1	33	56
	**O	4	15	21
Pupils are not willing to do homework	W	22	32	36
	O	5	20	15
Pupil's ability to understand demonstrations is poor	W	2	31	57
	O	1	13	26
Pupils do not read science material easily	W	18	55	17
	O	9	23	8
Pupils keep borrowed books at home and others cannot use them	W	2	15	73
	O	3	3	34
Slow pupils do not accomplish minimum work	W	25	42	23
	O	12	20	8
Superior pupils do not have enough to do	W	20	34	36
	O	11	17	12
Pupils do not want to handle live materials	W	4	21	65
	O	0	7	33
Behavior of pupils in class is unsatisfactory	W	7	27	56
	O	2	12	26
Pupils are neglectful of equipment and use it improperly	W	9	41	40
	O	3	24	13
Pupils are reluctant to bring materials and specimens to class	W	8	29	53
	O	4	12	24
Pupils are often unable to follow directions in laboratory	W	12	31	47
	O	4	18	18
Equipment is lost or stolen by pupils	W	2	12	76
	O	3	7	30
Pupils fail to see the relationships between laboratory work and regular class work	W	4	30	56
	O	2	8	30
Pupils have difficulty in understanding diagrams, drawings, and sketches	W	2	37	51
	O	0	12	28
Pupils are inadequately prepared to cope with science work	W	13	44	33
	O	3	15	22

* Washington science teachers.
** Oregon science teachers.

TABLE VII

NUMBER OF BEGINNING GENERAL SCIENCE TEACHERS REPORTING UPON INSTRUCTIONAL PROBLEMS RELATED TO TEACHING METHODS AND TECHNIQUES

Methods or Techniques with Which The General Science Teachers Were Experiencing Difficulties	Responses of Teachers: Yes	No
Planning the semester's or year's work	10	56
Following unit or course outlines devised by another	4	62
Using the text or workbook as the principal guide	4	62
Relating science and nonscience subjects	8	58
Coordinating sciences you are teaching with other classes in the school or district	13	53
Using teacher-pupil planning	26	40
Providing modified work for slow learners	47	19
Providing modified work for superior learners	35	31
Devising and using individual projects	33	33
Planning and using class projects	21	45
Planning and using suitable demonstrations	13	53
Planning effective assignments	8	58
Holding recitations and stimulating discussions	9	57
Taking field trips	35	31
Using supervised study	4	62

Using panels and committees	13	53
Having pupils give reports	9	57
Planning and using laboratory work	23	43
Using students as laboratory assistants	7	59
Using local resource persons	15	51
Using reviews effectively	5	61
Planning effective tests	2	64
Developing a satisfactory system of grading and evaluating	9	57
Planning and using pre-tests with units or course	7	59
Problem solving with class using research approach	14	52
Making short lectures effective	5	61
Using reference work	6	60

TABLE VIII

NUMBER OF BEGINNING BIOLOGY TEACHERS REPORTING UPON INSTRUCTIONAL PROBLEMS RELATED TO SCIENCE TEACHING MATERIALS

	Responses of Teachers		Responses of Teachers When Asked if the Deficiency Caused Problems	
Questions Asked	Yes	No	Yes	No
Do you consider the text reasonably adequate?	43	20	15	5
Do you have a text to assign to each pupil in each science class for his personal use at home and school?	57	6	5	1
Do you have an adequate number of supplementary textbooks, both elementary and advanced, for classroom use?	31	32	30	12
Do you have an adequate number of suitable reference books in the room where you teach science?	17	46	29	17
Do you have an adequate amount of usable material and equipment for individual or paired laboratory work by all the pupils at the same time?	21	42	26	16
Do you have an adequate amount of usable material and equipment when you need it for demonstrations?	41	22	15	7
Do you have satisfactory laboratory workbooks or guides for use by the pupils?	15	51	12	39
Does the school library have an adequate supply of science books and journals for each science you teach?	34	29	11	18
Do you have an adequate supply of usable charts for each science you teach?	31	32	13	19

TABLE IX

NUMBER OF BEGINNING PHYSICS AND CHEMISTRY TEACHERS REPORTING INSTRUCTIONAL PROBLEMS RELATED TO PHYSICAL FACILITIES

		Responses of Teachers		Responses of Teachers When Asked if the Deficiency Caused Problems	
Questions Asked		Yes	No	Yes	No
Is the room in which you teach science generally equipped for teaching that science?	*P	21	6	3	3
	†C	29	2	1	1
Do you have to change rooms to teach science?	P	6	21	5	1
	C	5	26	1	4

* Physics teachers.
† Chemistry teachers.

Is the chalkboard space adequate in each room where you teach science?	P	16	11	6	5
	C	23	8	3	5
Is the bulletin and display board space adequate in each room where you teach science?	P	13	14	7	7
	C	21	10	5	5
Are there adequate bookcases in each room where you teach science?	P	15	12	5	7
	C	18	13	5	8
Do you have an adequate means of converting electrical current to desired amounts and voltages?	P	6	21	10	11
	C	24	7	1	6
If you do not have a room equipped to teach science, do you have a movable science cabinet for transporting and storing materials?	P	0	6	0	6
	C	0	2	0	2
Are the physical aspects of each room in which you teach science arranged to permit movement of pupils with little confusion?	P	14	13	8	5
	C	18	13	6	7
Is adequate storage space available for your use in each room where you teach science?	P	15	12	7	5
	C	16	15	7	8

If you are teaching chemistry, how many hoods or hooded spaces are in the room?	Number of Teachers Having Each Number of Hoods	Deficiency Caused Problems	
		Yes	No
None	15	10	5
One	10	5	5
Two	3	1	2
Three	1	0	1
Four	1	1	0
Fifteen or sixteen	1	0	1

How many pupil stations (desks, tables and chairs) are in each room where you teach science?		Number of Teachers Having Each Number of Pupil Stations	Deficiency Caused Problems	
			Yes	No
Less than twenty	P	6	1	5
	C	7	0	7
Twenty-four or twenty-five	P	7	0	7
	C	8	0	8
Twenty-six or twenty-seven	P	1	0	1
	C	1	0	1
Twenty-eight or twenty-nine	P	3	0	3
	C	3	0	3
Thirty or thirty-one	P	5	0	5
	C	9	1	8
Thirty-two or more	P	5	0	5
	C	3	1	2

How many sinks are there in each classroom where you teach science?		Number of Teachers Having Each Number of Sinks	Deficiency Caused Problems	
			Yes	No
One or two	P	13	3	10
	C	7	1	6
Three or four	P	3	0	3
	C	8	3	5
Five or six	P	6	0	6
	C	8	2	6
Seven or eight	P	2	0	2
	C	2	0	2
Nine or ten	P	1	0	1
	C	1	0	0
More than ten	P	2	0	2
	C	5	0	5

How many standard electrical outlets are in each room where you teach science?		Number of Teachers Having Each Number of Outlets	Deficiency Caused Problems	
			Yes	No
None	P	2	2	0
	C	0	0	0
One or two	P	9	4	5
	C	5	0	5
Three or four	P	4	1	3
	C	9	3	6
Five or six	P	4	1	3
	C	3	0	3
Seven or eight	P	2	1	1
	C	1	0	1
Nine or ten	P	0	0	0
	C	2	0	2
More than ten	P	6	0	6
	C	11	0	11

How many gas outlets are in each room where you teach science?		Number of Teachers Having Each Number of Gas Outlets	Deficiency Caused Problems	
			Yes	No
None	P	2	0	2
	C	0	0	0
One or two	P	5	2	3
	C	1	1	0
Five or six	P	0	0	0
	C	1	0	1
Seven or eight	P	2	0	2
	C	4	0	4
Nine or ten	P	3	0	3
	C	1	0	1
More than ten	P	15	0	15
	C	24	1	23

How many pupil laboratory stations or tables are in each room where you teach science?		Number of Teachers Having Each Number of Laboratory Stations	Deficiency Caused Problems	
			Yes	No
None	P	3	3	0
	C	0	0	0
One or two	P	3	0	3
	C	2	0	2
Three or four	P	0	0	0
	C	2	0	2
Five or six	P	2	1	1
	C	3	1	2
Seven or eight	P	1	0	1
	C	3	0	3
Nine or ten	P	2	0	2
	C	1	0	1
Eleven or twelve	P	1	1	0
	C	3	2	1
Thirteen or more	P	15	2	13
	C	17	1	16

How many equipped demonstration tables are in each room where you teach science?	Number of Teachers Having Each Number of Demonstration Tables		Deficiency Caused Problems	
			Yes	No
None	P	7	3	4
	C	7	3	4
One	P	20	1	19
	C	23	1	22
Two	P	0	0	0
	C	1	0	1

TABLE X

NUMBER OF BEGINNING GENERAL SCIENCE TEACHERS SUGGESTING SOLUTIONS TO INSTRUCTIONAL PROBLEMS RELATED TO TEACHING METHODS AND TECHNIQUES

Suggested Solutions	Number of Teachers Selecting Each Solution
In-service training in county or district with regard to the following:	
Science teaching methods and curriculum	27
General teaching methods and curriculum	8
Specific sciences which you are teaching	12
Sciences other than those you are teaching	2
Further training at college with regard to the following:	
Science teaching methods and curriculum	33
General teaching methods and curriculum	7
Specific sciences which you are teaching	20
Sciences other than those you are teaching	9
Increased expenditures for equipment, books, and materials	41
Improved supervision and assistance	9
More experience; no additional training	15
Opportunity to visit and observe other science teachers	44
Participation in science curriculum extension courses	16
Independent study	14
Others	4

FACTORS AFFECTING THE HIGH SCHOOL STUDENT'S CHOICE REGARDING A SCIENCE CAREER *

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I. INTRODUCTION

THE objective of this study was to discover why students at the high school level choose to enter fields of endeavor other then science. It was believed that students have been exposed to certain conditions in the school which were of influence in their final choice of a career. Some of these factors may have been: (a) the interest in science shown by the teachers; (b) the guidance received by the students; (c) the provisions made by the school in regard to the facilities and the use of the laboratory as an instrument of learning; (d) the availability to the students of supplementary science activities; (e) the presentation by the school of the courses in science and mathematics necessary to provide students with the fundamentals in those areas.

II. PROCEDURES

To implement such a study, questionnaires were sent to a group of secondary

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schools of various sizes and locations. A number of schools in the State of Colorado were selected to receive these forms as well as a similar number of schools in various parts of the United States. Returns were received from a total of twenty-one schools involving the participation of twenty-one principals, sixty-five science teachers, twenty-four guidance counselors and 594 senior students. The students who took part in this study were selected from classes which would best provide a picture of the typical student. Some of them were interested in science but many were not. In addition to the information offered by the high school students, fifty-six college freshmen who were enrolled in the Basic Communication classes of the University of Denver also returned similar questionnaires for the purpose of comparison.

III. ANALYSIS OF THE DATA

As a result of personal contact with many principals as well as the information provided by the questionnaires, it appeared that a large proportion of these principals: (a) were not too well aware of the nation's critical need for personnel trained in science; (b) were more interested in keeping poorly qualified students out of science areas than in guiding potential scientists into the field; (c) were quite blind to the academic inadequacies of their science teachers as well as to the poor science teaching situations that were the result of inadequate laboratories, science texts, and supplementary science activities; (d) were apparently satisfied that courses in the physical sciences and advanced mathematics were available to all the students who desired them. Regarding this latter point, there was considerable evidence that in a number of the selected schools, the physical sciences and the more advanced courses in mathematics needed by students interested in a science career were offered only once or twice a day. The result of this procedure was that they often conflicted with courses regularly required for graduation thus denying to many students the opportunity to take them.

There was much evidence to indicate that a large number of science teachers: (a) were teaching a science which was not their speciality; (b) were in many cases teaching non-science subjects; (c) were in most cases carrying two or more periods of extra duty of a supervisory nature; (d) were providing no formal laboratory sessions along with their regular science classes; (e) were without even an undergraduate minor in the science they taught. In this latter respect, few of these teachers had taken any graduate work in either their teaching field, in related sciences including mathematics, or in the methods of teaching science. However, most of these science teachers had taken some graduate work in the area of professional education.

The guidance teachers were all quite well educated in their speciality, but for the most part indicated little interest in science. Most of them carried teaching and supervisory loads in addition to their counseling.

A large majority of the high school and college students who participated in this study were aware: (a) of the inadequate facilities and space in the laboratories; (b) of inadequate time for work in the laboratory; (c) and of the need for more supplementary science activities and science texts. The better science students indicated that they were constantly retarded by the slow pace set by the teacher. Many of these students recognized the academic unpreparedness of their teachers.

In response to a question regarding their interest in nine commonly taught grade school subjects, the overwhelming majority of these students listed reading, arithmetic, and science as the most interesting studied while they were at that level. About one-third of these students stated that while at one time they were inter-

ested in a science career, they had since changed their minds. Nearly all of them had done so while in the senior high school. The implication was that most students have a natural interest in science but that some place along their school career, particularly in high school, this interest was dampened. Most of these students did not take more than two courses each in mathematics and science between grades nine and twelve. The more science and mathematics a student took, the greater seemed his interest in a science career. There were a large number of instances where students had indicated interest in entering a science field but had, at the same time, taken less than two courses each in science and mathematics.

The principals, guidance counselors, science teachers, and high school students were in general agreement that the primary reasons students did not take more science while in high school were because: (a) science was too difficult and involved too much mathematics; (b) the student's background in science while in elementary school had been poor and uninteresting; (c) because the school offered so many important and desirable courses in competition with science that students found it difficult to make the proper choice. Apparently, the fact that science may have been considered more difficult than other courses was not the final reason why high school students were not taking them.

IV. RECOMMENDATIONS

The graduate schools in the nation should develop a Master of Science Teaching degree program designed specifically for secondary science teachers which would enable them to take a large part of their graduate studies in their teaching fields. Science courses carrying graduate credit which are fairly elementary would be necessarily a part of this program in view of the inadequate science background of many of these teachers. Such courses as Earth Science for Teachers, Organic Chemistry for Teachers, Human Anatomy and Physiology for Teachers, Survey of the Plant Kingdom for Teachers, etc. which ordinarily may not be offered for graduate credit should be acceptable toward a Master of Science Teaching degree. A refusal to do so only sends the teachers who need these more elementary courses back to the schools of education for a graduate program containing only courses in professional education. Certain courses in education may be fitted into these studies toward this degree including methods of science teaching. In a similar fashion, graduate schools may offer a Doctor of Science Teaching degree for the individual interested in college teaching. All the courses for this degree should be at the graduate level and consist of studies in specialized science areas supplemented with appropriate courses in professional education. The prime purpose of such a degree program would be to prepare scientists for college teaching and not just science research.

The undergraduate colleges involved in teacher preparation must offer a sequence of studies which will insure the elementary school teacher and the secondary school science teacher with the broad fundamentals of science. The future elementary school teacher must have at least acquaintance course work in general biology, human anatomy and physiology, conservation of our natural resources, physics, chemistry, earth science, and astronomy. Wherever possible, they should be expected to participate in individual laboratory work in order for them to develop an ease in the performance of classroom science demonstrations. Some background in the history of science and science teaching methods would also be helpful. They should have at least one general mathematics course along with methods of teaching arithmetic.

The student of secondary school science

teaching should take some individual course work in botany, zoology, human anatomy, and physiology, physics, chemistry, earth science, astronomy, and the conservation of our natural resources. Upon the completion of the basic courses in these areas, he should specialize, at least to the level where, upon graduation, he would be advanced enough to take the regularly designed graduate courses in science should be return for a master's degree. He should have college mathematics through calculus in additon to courses in the history of science and science teaching methods.

In order to attract better qualified people into science teaching, it may be necessary to provide them with a subsidy similar to that given teachers of agriculture. The position could also be made more attractive if the science teacher was relieved of non-teaching supervisory duties. Extra time would then be applied toward the building of a laboratory and a supplementary science activities program. The salary of the science teacher should be determined by merit rather than by time in service alone. Criteria, by which merit may be partially determined are: (a) the extent of the education of the teacher; (b) the accumulation of college credits in the subject of his teaching and related fields; (c) the nature of the science program developed by the teacher in his school; (d) the contributions made by the teacher to science and science teaching organizations.

The employment policies of school boards must be adjusted to meet the needs of the times. Able science teachers should not be retired or refused employment simply because they have passed a certain age level. Certainly unqualified science teachers should not remain in teaching because of tenure. They should be expected to improve their background within a reasonable period of time or be recommended to the school board for dismissal. As an aid to evaluate the science background of teachers, a neutral organization, such as the United States Office of Education should set up and sponsor a series of standardized examinations. Such examinations may be used by school boards as a guide to the evaluation of science teachers before employment as well as for those who have been with a school system for many years. In a similar way, the science background of the grade school teacher could be measured.

Elementary and secondary schools should have someone on the staff whose education in science would qualify him to be the school's science counselor. The duties of such a person should be, in part, to organize the science program at each grade level (particularly in elementary school) and to be that special person to whom science-interested students are sent for counseling.

It is suggested that the United States office of Education advise school boards and administrators of the manpower needs of the nation. This organization should take the lead in suggesting to the schools the nature of the science and mathematics program needed by students planning to enter a science career. It could also advise state boards of education and regional accrediting agencies of the science background needed by teachers of secondary school science as well by elementary school teachers. The United States Office of Education should help the states work out a system of reciprocity by which a teacher certified in one state would be automatically certified in all states.

The secondary school curriculum should include at least the four basic sciences; general science, biology, physics, and chemistry, and the five basic courses in mathematics: algebra one and two, geometry, trigonometry, and solid geometry. These courses should be available to all students desiring to enter science fields. At least one period a week for laboratory work or demonstrations should be formally set aside for each science course offered by the school.

It is recommended that, with local, state and federal aid, students interested in science be helped to pursue their studies through undergraduate, graduate, and even post-graduate school, should their potential for learning extend that far. In a similar manner, colleges and universities should be helped to establish programs which would attract top-flight scientists back to the schools for instruction and basic research.

V. CONCLUSION

Most young people in their formative years find things related to science of interest. Somewhere along their school career, this interest often wanes and may even be extinguished. The cause for this lies somewhere in the school, in the preparation of the teachers, in their psychology of teaching, in the facilities of the school plant, and in the guidance and motivation received by the students. A large part of the problem will be overcome when the school places on its staff scientists who are teachers and not just people who are science teachers. To aid in this respect, the positions for teaching science in secondary school must be made more attractive. Salaries should be more comparable with science positions outside of teaching. The teacher of science must be relieved of supervisory duties in order to spend more time in developing a laboratory and supplementary science program as well as to aid in the guidance and counseling of students interested in a science career.

EXTENT OF MATHEMATICS IN INTEGRATED PHYSICAL SCIENCE TEXTBOOKS FOR SECONDARY SCHOOLS *

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I. INTRODUCTION

Statement of the Problem

The problem of this study is to determine the frequency of mathematical processes utilized and included in the integrated physical science textbooks for the secondary school.

Hypothesis

The hypothesis of this study was as follows: In the integrated physical science course when mathematical concepts seem to give clearer understanding of text material, present textbooks appear to be deficient in mathematics.

Need for the Study

Many educators feel that science and mathematics must be taught in related form. Leonard [8] emphasizes this by saying that "in mathematics, he (the pupil) very soon realizes that the whole field of science depends heavily upon the quantitative aspect developed by the mathematician." Payne [11] states that "the relationship between science and mathematics makes integrated learning of the two subjects desirable. . . . Integrated learning is the learning act in which mathematics and science concepts are necessary for the solution of exercises in science."

Little material has been written on this subject concerning the secondary level, since as Mallinson and Buck [10] so succinctly wrote:

> It is indeed an unhappy conclusion, unavoidable as it may be, that there is a dearth of significant research with respect to the optimal science curriculum in the secondary school. The literature is replete with discussions of the need for a better general-education program. Further, there

* A continuing study based upon the author's unpublished master's thesis presented at Northern Illinois University.

are many opinions as to what the curriculum should include. However, there has been no systematic attack via research.

In Bullington's [3] research, he finds that "There is a need for research studies in the area of subject matter content for general education science courses."

II. PROCEDURE

Decision was made to survey all the textbooks available for the integrated physical science course at the secondary level to find the amount of mathematics included in each. The *Cumulative Book Index* [4] and the *Publisher's Trade List Annual* [12] were consulted to discover what textbooks were available. By checking the publisher's notation on each book and/or reading the preface in the textbook, differentiation between secondary and college textbooks was made, which revealed that the greater majority of physical science textbooks listed were intended for the college level course. Only three textbooks were found suitable for the secondary level. Updike [14] substantiates this when he says: "A search for physical science textbooks written on the high school level soon convinced us that few were available." For further information, inquiry was made as to the availability of secondary level physical science textbooks through private interviews with representatives (displaying only science and mathematics textbooks) of the major textbook companies. It was learned from this source that more textbooks for such a course should be forthcoming at the beginning of this year (1958).

An outline of the basic and essential fundamental mathematical processes was made, using as a basis three mathematics textbooks especially designed to teach fundamentals of mathematics: Boyer [1], Hooper [7], and Richardson [13]. The determination of these processes was made on the basis of frequency and for confirmation, the study made by Leonhardy [9] was consulted.

Each textbook was surveyed, page by page, to determine the available mathematical interpretations of physical phenomena and discerning, according to Table I, the mathematical concept employed therein. A frequency count was taken for each physical science textbook. Due to the nature of the page lay-out of the three textbooks, it was necessary to differentiate between the mathematical processes set apart from the text matter and those included in the text material. The methods used in determining the mathematical processes present can best be described by the following cases employed by an author of one of the three textbooks used in the survey. In the method for the determination of horsepower, Eby [5] uses

$$\text{hp} = \frac{\text{F x D}}{\text{33,000 x T (min)}}$$

or

$$\text{hp} = \frac{\text{F x D}}{\text{550 x T (sec)}}$$

In these particular cases, they would be formulae. Consequently, the processes used would be multiplication and division when the author went on to give the following example: the horsepower required to raise a loaded elevator, weight equal to 1650 pounds at the rate of 240 feet per minute for one second is solved by

$$\text{hp} = \frac{1650 \text{ x } 4}{550 \text{ x } 1} = 12 \text{ horsepower.}$$

The results of this frequency count are recorded in tabular form under the name of the textbook authors as against the mathematical process as listed, and can be found in Table I: Frequency Distribution of Mathematical Processes in Certain Physical Science Textbooks.

III. RESULTS

Table I presents a tabular form of the results of this study, whereas the synthesis and analysis of data follows the table.

TABLE I

FREQUENCY DISTRIBUTION OF MATHEMATICAL PROCESSES IN CERTAIN PHYSICAL SCIENCE TEXTBOOKS

Mathematical Processes [a]	Frequency of Use				
	Textbook				
	1 [2]		2 [5]		3 [6]
	S.A.[b]	T.M.[c]	S.A.	T.M.	T.M.
1. Fundamental Operations					
a. Addition	0	2	2	0	0
b. Subtraction	0	2	1	1	2
c. Multiplication	6	11	1	12	10
d. Division	4	5	0	9	16
e. Averages	1	0	0	0	0
f. Exponents					
(1) Postive and negative	1	0	0	1	0
(2) Powers of 10	0	2	0	0	0
g. Radicals and Roots					
(1) Square Root	0	1	0	0	0
h. Relations (Ratios)					
(1) Direct Proportion	0	2	1	0	3
(2) Inverse Proportions and Reciprocals	1	0	2	1	1
(3) Ratios	—	—	0	4	—
2. Decimals					
a. Percentage	1	2	0	0	1
b. Scale Drawing	0	0	1	0	0
3. Fractions					
a. Multiplication	0	2	0	0	2
4. English and Metric Systems					
5. Algebra					
a. Formulae	5	5	3	6	14
b. Graph, plotting of	1	0	1	0	1
c. Equations					
(1) Linear	—	—	0	1	—
(2) Quadratic Solutions by: (a) formula	—	—	0	2	—
6. Plane Geometry					
a. Vectors					
(1) Addition by parallelogram method	1	0	1	0	0
(2) Graphical method	0	0	1	0	0
(3) Components	—	—	1	0	—
b. Angles (time)	0	1	0	0	1
7. Trigonometry					
8. Logarithms					

[a] Mathematical Processes without frequenty count:

1. Fundamental Operations—Roots (other than Square Root).
2. Decimals—Addition, Subtraction, Multiplication, Division, and Percentile 7rror.
3. Fractions—Addition, Subtraction, and Division.
4. English and Metric Systems—Use of Numbers in Measuring (Approximate Numbers and Significant Numbers).
5. Algebra—Direction (Negative Numbers), Monomials, Binomials, and Quadratic Equations (factoring).
6. Plane Geometry—Vectors (Addition by triangular method), Circles, Ellipse, Tangent.
7. Trigonometry—Solution of Triangles (Right and Oblique), Indirect Measurement (Sine, Cosine, Tangent).
8. Logarithms—Use of Log Tables, Computations with Logs (Solution of Right Triangles, Oblique Triangles), Application of Logarithms (Slide Rule).

[b] S.A.—Set apart from text material.

[c] T.M.—Included in text material.

Each textbook was considered separately to obtain an interpretation of its results.

Textbook 1

The total frequency count of textbook 1 was 56, which included both those items set apart from the text material and those included in the text material. The fundamental operations add the greatest number to the final total with 38. Although multiplication and division scored 17 and 9, respectively, eight of the other operations scored 1 or 2. The only section of decimals covered was that of percentage (3). The only process in fractions was multiplication which totaled 2. The plotting of a graph (1) and formulae (10) made up the algebra section, and the addition of vectors by the parallelogram method (1) and time angles (1) were all that plane geometry included. Trigonomentry and logarithms were completely neglected.

Textbook 2

For textbook 2, the total frequency count was 52. There were a total of 27 fundamental processes which were set up in the same manner in this textbook as was done in textbook 1. Multiplication led with 13 while division (9) and relations (8) followed closely behind. Only three other processes in this section total 1 or 2. Scale drawing in decimals scored only once. No fractions were in evidence here. Formulae in algebra, a count of 9 was made, while equations accounted for 3 and the plotting of a graph (1) for the remainder of algebra. Vectors totaled 3 for plane geometry. Trigonometry and logarithms failed to appear in this textbook.

Textbook 3

This textbook differed in that there was only text material in which to find the mathematical processes. The total number of processes located was 51, of which 32 were fundamental operations. Multiplication (10) and division (16) made up the greater part part while relations (4) and subtraction (2) made up the difference. Percentage totaled 1 and multiplication of fractions totaled 2. In algebra, formulae led with 14 and the plotting of a graph followed with 1. Only time angles (1) counted for plane geometry. Neglected were trigonometry and logarithms.

Synthesis of Data

The synthesis of data revealed that only four processes out of the fifty-one set up in the frequency count had a substantial number of counts. Those were (of the fundamental processes) multiplication, division, and relations, while formulae also counted heavily in the algebra section. With fifty-one processes set up in the table, the total frequency counts totaled only 56, 52, and 51 respectively. All these mathematical processes are suitable for use in the integrated physical science course, and the evidence found in this study seems to definitely indicate a lack of mathematical content in the only available textbooks for such a course on the secondary level.

IV. SUMMARY

The problem of this study, to determine what mathematics was included in the integrated physical science textbooks, was solved by an extensive and carefully prepared analysis of each textbook. The results of the analysis seemed to indicate the accuracy of the hypothesis (which stated that a deficient amount of mathematics was included in the specific textbooks): first, of 51 mathematical processes tested for, only four processes were used to any extent; second, in no textbook were there more than 56 items included in the 51 mathematical processes; third, all the mentioned mathematical processes are suitable for use in the integrated physical science course. Thus, the above data indicates these above processes were used to a minimal extent, if at all.

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PLANNING A STUDENT TEACHING PROGRAM FOR PROSPECTIVE HIGH SCHOOL SCIENCE TEACHERS *

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THE PROBLEM

THE purpose of this study was to determine the nature and status of student teaching programs in science and through a critical analysis and interpretation of present policies and practices, to propose an improved program for student teaching in science at the high school level. This study was limited to the student teaching programs in high school science as offered by the colleges and universities of the state of Ohio, which are approved for teacher certification by the State Department of Education, and which had students enrolled in student teaching in high school science during the academic year 1952–53.

Principles, objectives, and methods of teaching were studied only as needed to clarify the student teaching problem.

Data for this document were obtained through the use of three forms of a questionnaire and through personal interviews. The personnel consisted of college and university directors of student teaching and college and university supervisors of student teaching, high school supervising teachers in science, and student teachers assigned in high school science in the laboratory and/or cooperating high schools of the colleges and universities participating in this study. Thirty-two of the 44 colleges and universities which had students enrolled in student teaching in science in the academic year 1952–53 participated in this study.

Of the 360 copies of the questionnaire forms which were placed in the hands of

* A paper presented at the meeting of the National Association for Research in Science Teaching, Atlantic City, New Jersey.

the personnel participating in this study, 188 were completed and returned.

MAJOR FINDINGS

Supervision of student teaching at the high school level by college and university supervisors, in general, is in addition to a full teaching schedule for the supervisors in the institutions represented in this study.

Approximately two-thirds of the institutions enroll 50 or fewer students in student teaching per year in all subject areas including seven students assigned in science. The typical institution utilized from one to three public high schools for student teaching. The typical high school utilized for student teaching enrolls 800 or fewer pupils in the upper six grades and three or fewer student teachers are assigned to it in science.

The only requirements for admission to student teaching which are common to all institutions are (1) that the student has attained senior standing or above, and (2) has a minimum scholastic record of C.

In general, opportunities for co-curricular experiences are very limited for students during their student teaching assignments.

Student teachers are usually free in the selection of instructional materials as well as methods of teaching.

Several experiences in the use of the laboratory are afforded student teachers although opportunities are not provided for all of the more common types of experiences.

Supervising teachers in high school science usually have one student teacher each under their supervision per semester or per quarter. A majority of these student teachers are science majors.

In a large majority of the cases studied students were assigned to student teaching in representative schools, i.e., schools in which the pupil population is non-selected.

Over 80 per cent of the institutions represented in this study assign student teachers for a period of 14 to 18 weeks to one school.

In general, the students represented by the institutions participating in this study were not assigned to full-time student teaching.

Little provision is made in a large majority of the participating institutions for flexibility in professional laboratory experiences, especially in student teaching assignments.

In a majority of the participating institutions, observation of classroom procedures constitutes the chief kind of professional laboratory experience prior to student teaching assignments. Professional laboratory experience programs are in the developmental stage in a majority of these institutions.

Opportunities for professional laboratory experiences on the part of student teachers, aside from responsible classroom teaching, are, in general, very limited.

CONCLUSIONS AND RECOMMENDATIONS

All professional laboratory experiences should have continuity and should be integrated more closely with college courses throughout the four years of college.

There should be many professional laboratory experiences, the nature and number of these to be determined by the needs, interests, and abilities of the individual student teachers.

As one important phase of the professional laboratory experiences, students should observe classroom procedures in connection with professional education courses.

There should be more opportunities provided for student teachers to observe classroom procedures during the period in which they are assigned to student teaching.

More opportunities should be provided for student teachers to direct and assist in co-curricular activities within the high

schools to which they have been assigned. More opportunities should be provided for student teachers to have experiences with school community activities.

Opportunities should be provided for student teachers to participate in all of the professional experiences in which regularly employed teachers engage.

Students should be assigned to student teaching only upon the satisfactory completion of designated content and professional education courses. In addition, there should be satisfactory reports on general and science competency tests and pre-student teaching professional laboratory experiences. Participatory experiences, i.e., working with youth in order to study their behavior, should be a required phase of the professional laboratory program.

There should be a report indicating the satisfactory passing of a health and physical examination by all candidates for student teaching. Satisfactory reports regarding a speech and hearing test should precede admission to student teaching.

All students should be assigned to student teaching in laboratory and/or cooperating high schools which are as representative as practicable in order that they may have experiences in the guidance of non-selected groups of youth.

In order that there shall be a broad experience, students should be assigned to student teaching in more than one science subject in which they will be certificated. These assignments should be at different grades levels, if practicable, preferably one assignment at the junior high school level and another at the senior high school level.

Students should be assigned successively to student teaching in more than one school. If practicable, students should be assigned to student teaching in laboratory and/or cooperating high schools in which the enrollment varies considerably.

Student teaching assignments should extend over a considerable period of time in order that there may be continuity in the study of a given school by the student teacher assigned to it.

There should be provision for greater flexibility of time devoted to student teaching. Provision should be made for increasing or decreasing the total number of weeks devoted to student teaching on the basis of progress of each student teacher as determined co-operatively by frequent evaluations of college or university supervisors and the supervising teachers.

There should be further recognition of individual differences among student teachers. If these differences are taken into account, not all students will enter student teaching at the same point in the professional sequence. The needs, interests, and abilities of the individual student teacher should determine the variations within the student teaching assignment.

Some full-time student teaching, i.e., spending the entire school day in a given laboratory and/or cooperating high school for a period of consecutive weeks, should be within the experience of every student teacher. During this period, the student teachers' entire college programs should center around experiences related to student teaching.

The assignment to full-time student teaching should extend over a period of time sufficiently long to give ample opportunity for the student teacher to study and observe pupil progress resulting from his guidance.

There is need for student teachers to become better acquainted with library facilities and also with science laboratory equipment and supplies in the laboratory and/or cooperating high schools to which they are assigned.

College and university supervisors of student teaching cooperating with the supervising teachers in the laboratory and/or cooperating high schools should provide more adequate orientation of student teachers in regard to the school communities to which they are assigned. Acquaintance

with the community resources that are available for school use should be a definite phase of such orientation.

Instructional loads of college and university staff members, assigned to supervisory duties, should be adjusted to provide time for more adequate supervision of student teaching.

Guidance and evaluation of professional laboratory experiences including student teaching should be the joint responsibility of college or university supervisors of student teaching and the supervising teachers.

In general, it is believed that the colleges and universities of Ohio that follow the above recommendations will effect an improvement in their student teaching programs in science.

A COMPARISON OF THE RELATIVE EFFECTIVENESS OF TWO METHODS OF TEACHING A COURSE IN PHYSICAL SCIENCE TO SOPHOMORE COLLEGE STUDENTS *

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THE NATURE OF THE STUDY

A RECOMMENDED objective of science instruction is the development of a method of thinking by the students. However, few research studies dealing with this objective reveal any evidence of how students do think. One of the major purposes of this study is to determine whether the method of thinking about problems used by students changes as they progress through a course in physical science. Since the achievement of functional information or facts, fundamental concepts, instrumental skills and a functional understanding of principles are also objectives of science instruction, the second major purpose of this study is to determine student achievement of these objectives in the course as measured by standardized tests to be described.

The experimental method of teaching to be compared with a lecture demonstration method is essentially a problem-solving method. It will involve teacher-pupil planned experiments designed to yield data which may provide a reasonable answer to specific questions.

* A paper presented at the meeting of the National Association for Research in Science Teaching, Atlantic City, New Jersey.

NEED FOR THE STUDY

Science educators have long advocated the teaching of science in a way which will help students develop a method of thinking about their everyday life problems. This method is the scientific method of problem solving. Many of the Yearbooks and Committee Reports [1, 2, 3] are in agreement in accepting as objectives of science instruction the understanding of the scientific method and the obtaining of competence in its use. These are the objectives of the problem-solving method of teaching to be used in this study.

It has been shown [4] that the scientific method consists of certain definite elements known and used by scientists which are distinct from scientific attitudes. The Thirty-Seventh Yearbook of the National Society for the Study of Education [5] recommends that studies be undertaken which investigate the processes of learning by using the methods of science in solving problems of everyday life. The report of the Progressive Education Association [6] states that young people can only be encouraged to use the scientific method of thinking by varied successful experiences in the method of attacking problems arising from "novel"

life situations. The problem solving method to be used in this study will require students to make extensive use of the scientific method in planning and carrying out experiments to obtain answers to questions related to such situations.

A review of the literature reveals that previous research has determined the elements of the scientific method and has shown that students ability to use certain of these elements can be improved as a result of instruction [7]. However the effectiveness of a problem-solving method of teaching a course in physical science in which the major emphasis is on the use of the scientific method by the students has not been determined. Furthermore in these studies in which attempts have been made to teach the scientific method as a means of problem solving, the emphasis has been on getting the "right answer" rather than on the manner of achieving the answer. This study will be concerned with determining the manner in which students try to obtain answers to questions. Tape recordings of discussions of the planning and carrying out of the experiments will be analyzed to obtain data concerning the method of thinking used by the students.

RELATED STUDIES

The research studies referred to below all deal with problems similar to those of the proposed study. The way in which this study fits into the pattern of educational research is indicated by pointing out the significant differences between the proposed study and some of those already completed.

Boeck [8] used a method of instruction in the chemistry laboratory which involved pupil planning of controlled experimental laboratory procedures. The learning activities which the pupils will plan in this study are not limited to formal laboratory problems. In a study reported by Beer [9] children in the primary grades were encouraged to find answers to questions and problems by experimenting. The author states that the children developed the habit of forming conclusions from facts they had learned rather than jumping to conclusions. The proposed study will attempt to determine evidence of changed behavior of students in regard to many other elements of the scientific method. Studies by Weismann [10] Teichmann [11] and Alpern [12] dealt with specific elements of the scientific method. The investigator in this study will attempt to obtain data concerning all the elements of the scientific method which are involved in the planning and carrying out of experiments.

Since the investigator is interested in obtaining data concerning the changes in behavior of students, the studies of Hill [13], West [14], and Perkins [15] which describe methods which were successful in revealing meaningful data in regard to student behavior have significance for this study.

PROCEDURES RELATED TO

The Methods of Instruction

Since the experimental factor in this study is the method of instruction, the distinguishing features of the two methods being compared must be clearly indicated. One of the major differences between the two methods will be the kinds of classroom activities engaged in by the experimental groups and the role of the instructor in these activities.

The instructor of the control group, using essentially a lecture demonstration method, will be primarily interested in presenting logically organized subject matter, regarding other objectives such as problem solving skills to be achieved concomitantly. The students of the control group will complete sequentially assigned textbook readings and find answers to questions listed in textbook and workbook. The instructor of the experimental group, using essentially a problem solving method, will strive to develop student competence in the use

of the scientific method of problem solving by having the students attempt to solve specific problems. The students will be guided toward achieving the objectives of the course through the development performance and discussion of teacher-pupil planned experiments. The experiments are designed to obtain data on which the students may make tentative conclusions in answering selected questions which are related to their everyday activities, such as purchasing sun glasses. Unlike the control group the science information will not be sequentially organized but whatever body of information is needed for the development of the experiment will be developed without regard to formal science areas.

In order to determine the actual differences between the methods of instruction, tape recordings of complete class sessions of both the control and experimental groups will be obtained at frequent intervals throughout the year of instruction.

Tests

The data needed for comparing student growth in such objectives as subject matter achievement, instrumental skills, application of principles and critical thinking will be obtained by administering appropriate standardized tests described below at the beginning and end of the year of instruction to both the experimental and control groups. Data regarding the validity and reliability of these tests are available [16].

Test of Application of Principles of Physical Science: Cooperative Test Bureau

This test consist of five problem situations. The student is to indicate agreement, disagreement or uncertainty as to agreement with a conclusion regarding each situation and to justify his decision by selecting logical reasons from a list of statements of authority, analogy, principles of science, etc. accompanying each situation. The test yields data on a student's ability to apply principles of science to new situations.

Interpretation of Data Test: Cooperative Test Bureau

This test consists of ten sets of data selected from various fields presented in the form of tables, charts, graphs or prose descriptions, each set followed by statements which purport to be interpretations of the data. The student is asked to make one of five possible judgments regarding the truth or falsity of each statement thereby indicating his ability to perceive relationships in data and to recognize limitations of data.

Watson Glaser Critical Thinking Appraisal: World Book Company

The test is divided into five sub-tests which require the student to apply such critical thinking abilities as judgment of inferences, recognition of assumptions, deductive reasoning, interpretation of data and evaluation of arguments to selected problems. The emotional impact of the subject matter involved in the problems is such that any lack of objectivity on the part of the students will result in a reduction in the total test score.

Test of General Proficiency in the Natural Sciences: Cooperative Test Bureau

Of the two parts of this test, Part I attempts to measure, through multiple choice items, the student's knowledge of fundamental terms and concepts of science; while Part II tests the student's comprehension of science material and his ability to interpret and use the information in new situations.

These four tests were selected for use in this study because they reflected the content and objectives of the course in physical science at Danbury State Teachers College. A jury of selected science teachers was asked to judge the validity of each

test for use in this study in terms of specific criteria.

Treatment of the Test Data

The statistical procedures used in this study will be those of standard small sample theory [17]. The t-statistic will be calculated on the 5 per cent level of confidence to determine the significance of the differences of the means of each sample in each of the initial and final tests.

The Chi-square statistic will be used to determine whether any relationships exist between gains made by the students between initial and final tests and such factors as intelligence, sex, and science background.

Tape Recordings—Post Session Reaction Sheets

As stated earlier, one of the purposes of the study is to determine whether the method of thinking about problems used by students changes as they progress through the course. The technique to be used in obtaining data in regard to the problem solving behavior of students will involve making tape recordings of various complete class sessions of both the control and experimental groups. Post session reaction sheets consisting of questions which are designed to elicit evaluative reactions of class activities will also be used. This technique of obtaining evidence of student behavior was tried out in a pilot study and found to yield evidence of problem solving behavior.

Analysis of Tape Recordings

The student statements and questions recorded on the tapes must be converted into meaningful evidence of problem solving behavior on the part of the students. The tape recordings will be played back and analyzed with the aid of a check list of problem solving abilities developed by Teichman [18]. The number and kinds of statements which indicate types of problem solving behavior (see check list appended) will be noted. The changes in the total number and kinds of such statements made by each student on successive recordings will be noted. From this data and that of the post session reaction sheets, a pattern of the problem solving behavior of each student as he progresses through the course will be estimated.

SPECIFIC ABILITIES INVOLVED IN PROBLEM SOLVING

NOTE: This analysis is taken from the doctoral thesis of Louis Teichman, entitled, *Ability of Science Students to Make Conclusions.* Ph.D. Thesis, New York University, 1942.

A. Perceiving a Problem.
  1. Ability to recognize a conflict with previous experience.
  2. Ability to select problems from groups of statements.
  3. Ability to state problem in his own words.
  4. Ability to define the problem.
  5. Ability to break up large problems into their smaller constituent problems.
  6. Ability to select the pertinent part of a problem
  7. Ability to select a problem from a paragraph.

B. Relating to Previous Experience.
  8. Ability to recall facts.
  9. Ability to recall generalizations.

C. Formulating Hypotheses.
  10. Ability to infer.
  11. Imaginative ability.
  12. Ability to select most logical guesses.
  13. Ability to discard illogical hypotheses
  14. Ability to relate cause and effect.
  15. Ability to differentiate among hypothesis, fact, superstition, and theory.
  16. Ability to recall related experiences.
  17. Ability to classify.
  18. Ability to state hypotheses.

D. Testing the Hypotheses.
  19. Ability to organize data.
  20. Ability to recognize fallacies and contradictions.
  21. Ability to establish experimental controls.
  22. Ability to manipulate.
  23. Ability to differentiate between procedure, observation, and inference.
  24. Ability to use scientific apparatus.
  25. Ability to use measuring instruments.
  26. Laboratory resourcefulness.

27. Ability to recognize the adequacy of proof.
28. Ability to devise experiments.
29. Ability to discard irrelevant hypotheses.
30. Ability to observe accurately and completely.
31. Ability to invent check experiments.
32. Ability to isolate the experimental factor.
33. Ability to persist in the search for facts.
34. Ability to predict.
35. Ability to perceive resemblances and configurations.
36. Ability to make comparisons.
37. Ability to question data.
38. Ability to assess the reliability of authorities.

E. Deriving a Conclusion.
39. Ability to generalize from specific data.
40. Ability to relate conclusions to the original problem.
41. Ability to understand the relationship of facts to larger items.
42. Ability to interpret experimental data.
43. Ability to summarize data.
44. Ability to state conclusions.
45. Ability to base judgments on facts.
46. Ability to judge adequacy of facts.
47. Ability to evaluate conclusions in the light of facts.

F. Application.
48. Ability to identify a principle or principles used in a given case.
49. Ability to use generalizations in interpreting new situations.

G. Other Related Abilities.
50. Ability to understand mathematical relationships.
51. Ability to use mathematical techniques.
52. Ability to interpret pictorial material.
53. Ability to work in a neat and orderly fashion.
54. Ability to get meaning from new material (general reading ability)
55. Skill in getting the sense of a written message.
56. Skill in writing.
57. Skill in speaking.
58. Skill in the use of library facilities.
59. Ability to read for understanding.
60. Ability to read for retention.
61. Ability to skim.
62. Ability to interpret graphic materials.
63. Ability to use the dictionary.
64. Ability to understand scientific terms.

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CHANGES IN STUDENT CONCEPTS OF PROCEDURES USED IN DETERMINING CLASSROOM EXPERIENCE IN A GENERAL SCIENCE COURSE *

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SCIENCE as it has generally been taught in the schools has been presented largely as a content experience. Students study various subjects in which there is a well developed subject matter program to be covered during the school year. There are few opportunities in which students may learn to develop procedures for organizing their experiences to influence conditions which will effect them at a later date.

When we speak of science, we may think of both an organized body of knowledge and a method or process. Method and process refer to the organization of experiences in such a manner that certain meanings are arrived at, which lead to prediction and control. This prediction aspect develops as we extend the meanings of our organization of experience. It results from our organization of experience; it also tends to give direction and meaning to our own experience. This aspect of science has received but limited recognition in science programs in secondary schools. Such an emphasis may assist students in developing systematic approaches for dealing with various situations which may have meaning for the individual in the future.

This study was developed to obtain evidence of changes in the manner in which students organize their experiences as they participate in determining curriculum experiences in a general science course. The study was designed to evaluate what changes could be realized within a school year in a subject-centered curriculum. Two groups of seventh grade students took part in the study. They are referred to as the A and B sections. The students met for four forty-minute periods each week. There was no prescribed syllabus for the course. The students had had little previous organized science experiences.

RESEARCH PROCEDURE

Periodically students were presented with a broad structural framework to provide direction to their planning efforts. Within this structure students considered what things they felt they wanted to do. After arriving at various decisions about these matters, a study guide was developed which directed daily work for this planned period. The students were asked to respond individually to a series of questions presented at particular times. One set of questions was used as a partial basis for arriving at decisions about the materials being considered by the class. Another set was used to evaluate the planning sessions. Still another set was used to evaluate the experiences which had developed from the decisions made during the planning period. Students responded individually to the questions. Feedback of individual reactions was used on occasions for group evaluations.

During the planning sessions, students made various suggestions about what the class might do as a group. The students arrived at decisions about the suggestions, using various procedures to do this. They then evaluated the planning sessions; at a later date, they evaluated the experiences which had developed as a result of the decisions arrived at in the planning session. These experiences were provided to help

* A paper presented at the meeting of the National Association for Research in Science Teaching, Atlantic City, New Jersey.

students recognize relationships which might exist between the manner in which the decisions were made and the kinds of experiences which developed from the decisions. The recognition of such a relationship might produce concern for improving the procedures being used in making decisions.

The study was developed to evaluate the extent to which students learn to recognize this relationship and the kinds of procedures that they may develop in arriving at decisions about their work as a group during a school year. The teacher was interested in helping students understand the usefulness of extending the meanings of individual suggestions in terms of their anticipated consequences as a basis for making decisions. Previous experiences could be organized as student suggestions were considered for prospective meanings. The students after an examination of the prospective meanings of the suggestions might be better able to arrive at decisions about which experiences they wanted to have.

Five areas were investigated to secure evidence of changes in the thinking of the students as a result of their participation in these planning and evaluation experiences. The areas are presented with the hypothesis that prompted their investigation. With each of the areas, general findings are presented. During the experimental period, 26 sets of student responses were received from the A section; 22 sets of student responses were received from the B section. The evidence generally consisted of changes in the distribution of classified student responses over periods of time. In each of the areas of investigation, categories were developed to classify the responses. Student reactions were then categorized for sets of responses received at different times during the experimental period. Several sets of responses were used to indicate trends as well as to point out the developmental nature of any changes.

AREAS EXAMINED

Area I. To what extent are students willing to postpone reaching decisions about their work until they have had opportunities to consider tentative experiences indicated by the suggestions of the students.

Hypothesis. As students share responsibilities for determining and evaluating their experiences, they become aware of the need to postpone their decisions in the matter until they have had an opportunity to consider the nature of their involvement.

Findings. At the beginning of the study, whenever students had opportunities to reach decisions about their work, they viewed this as simply a matter of expressing their individual interests. Classification of student responses to questions in this area during the year produced evidence of changes in student conceptions about these matters. Student responses were classified as to whether they indicated a desire to postpone reaching decisions until the students could examine the suggestions before coming to a decision about them.

At the beginning of the experimental period, all the student responses indicated a desire to come to a decision immediately. At the end of the period, approximately 90 per cent of the student responses were classified as indicating a desire to postpone making decisions until the suggestions could be examined or processed by the group.

Area II. To what extent do students in their evaluations of their planning sessions and in their evaluations of the experiences which develop from the planning sessions indicate recognition for the usefulness of systematic procedures in arriving at decisions about their experiences in class.

Hypothesis. As students recognize the influence of the use of various procedures in arriving at their decisions in developing their experiences, they will demonstrate

a greater concern for the manner in which they reach their decisions.

Findings. There were significant increases in the percentages of responses classified as recognizing process during the experimental period. During this period, there was an increase in the proportion of student evaluation responses that were concerned with examining and processing suggestions before reaching decisions. At the same time, there was a decrease in the number of responses that rejected the processing of suggestions and a decrease in the number of responses that referred only to the mechanics of the process—time used, amount of talking, etc. There was an increase of approximately 40 per cent during the period in the number of responses classified as recognizing process.

Area III. To what extent do students examine suggestions in terms of the predicted activities that might develop before arriving at decisions about these suggestions.

Hypothesis. As students share the responsibilities for developing their classroom experiences, they become increasingly aware of the need to develop meanings of the suggestions in terms of their consequences for the future in establishing decisions about the kind of experiences they want for the future.

Findings. During the experimental period, there were significant shifts in the distribution of student responses. The percentage of responses categorized as indicating a desire to discuss the suggestions (consider the prespective consequences) before coming to a decision had increased from 0 per cent to approximately 90 per cent in both groups of students.

There was also evidence regarding the nature of the changes in student attitudes regarding decision making. Initially, students viewed decision making experiences largely as opportunities for expressing their preferences. Later, the students seemed to look upon these experiences as a means of eliminating undesirable suggestions from their agenda. Finally, many students seemed to look upon these planning experiences as opportunities for determining which of the suggested experiences seemed to offer the most rewarding opportunities for the future. In other words, the students acted in a more responsible manner at the end than at the beginning of the experimental period.

Area IV. To what extent is the student's conception of the teacher as an authority figure replaced by a conception of the teacher as a resource person.

Hypothesis. As students share responsibilities for developing classroom experiences based on their decisions arrived at with reference to the anticipated consequences, they find use for the teacher's experiential background in helping them examine the suggestions before arriving at their decisions.

Findings. During the experimental period there were significant changes in the distribution of student responses within the system of categories developed. The responses were analyzed and classified under one of the following categories:

(1) Response indicates that the student's conception of the teacher is one of a rigid authority in the process of arriving at decisions.

(2) Response indicates that the student wishes to exclude the teacher from the decision making process.

(3) Response indicates that the student's conception of the teacher's function in the process of arriving at the decision changed during the process.

(4) Response indicates that the student's conception of the teacher is one of a resource person who helps them in particular ways in developing their decisions about their work.

At the beginning of the experimental period, the student responses were distributed fairly evenly among the four categories. At the end of the experimental period, approximately 90 per cent of the student responses in the A section and approximately 60 per cent of the student responses in the B section were classified as indicating recognition of the teacher as a resource person.

Additional data clarified the difficulties

that many students experienced in developing a conception of the teacher as a resource person. The students felt strongly that they should be allowed to determine their classroom experiences. They also recognized the experiential background of the teacher. These two tendencies seemed to register as a conflict in the thinking of many students. When they were able to resolve this conflict, they seemed to be able to view the teacher as someone who because of his experiences could help them in determining what they might do in class.

Area V. To what extent do students associate themselves as influencing agencies in processing the suggestions before making decisions about their work.

Hypothesis. As students share responsibilities for developing classroom experiences based upon decisions made by considering prospective consequences of their suggestions, they become increasingly aware of their individual influence upon the proceedings.

Findings. Several groups of student responses to questions dealing with the manner in which the students individually influenced the decisions were analyzed and classified under one of the following categories:

(1) Response indicates that the student recognizes his individual influence upon the process of arriving at the decisions.

(2) Response indicates that the student recognizes the procedures and in arriving at the decision, but fails to recognize his own influence upon the process.

(3) Response indicates that the student fails to recognize the use of any procedures in arriving at the decisions.

At the end of the experimental period, there were increases of approximately 50 per cent in the distribution of responses classified as indicating individual influence upon the process of arriving at the decision. More students seemingly began to recognize the manner in which they affected the proceedings as the group arrived at the decisions about their work.

The findings presented in this paper indicated that the students had realized certain developments in the areas investigated. Students may learn to postpone their involvement in situations until they have had opportunities to examine the meaning of various elements in the situation. They may also learn to recognize the relationships between the procedures used in making decisions and the kinds of experiences which develop from these decisions. It is important that the student learn to recognize himself as an agency of influence in developing these experiences. In this regard, it is also important to understand the use of resources and resource people. The changes realized would seem to have influenced the individuals in ways which may render them more effective in relating themselves within situations whose developments may continue to influence them.

ADAPTING SCIENCE INSTRUCTION IN NEW YORK CITY JUNIOR HIGH SCHOOLS TO THE NEEDS OF PUERTO RICAN PUPILS *

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THERE are at present over 113,000 pupils of Puerto Rican background in the public schools of New York City. Although American citizens, these children are Spanish-speaking and their culture has its roots in the earliest settlements of the New World.

* A paper presented at the Thirtieth Annual Meeting of the National Association for Research in Science Teaching, Hotel Claridge, Atlantic City, New Jersey, February 15, 1957.

However, within the same age groups, Puerto Rican pupils present marked differences in background, in years of schooling, and facility in the English language. This increases the difficulties that confront teachers and supervisors in trying to serve the needs of these children.

The Puerto Rican Study, sponsored by the Board of Education of the City of New York under a grant-in-aid from the Fund for the Advancement of Education, has been studying different phases of this problem. Under the direction of Dr. J. Cayce Morrison, it has during its four years of existence, developed new ways, methods and techniques in different areas of study which will help the public schools in meeting the needs of the Puerto Rican pupils.

The Science Program developed under the Puerto Rican Study grew out of the recognition by the Board of Education that science plays a vital role in the orientation and adjustment of the newly-arrived Puerto Rican pupils. The problem was to determine how science instruction can be adapted to the needs, interests, and abilities of Puerto Rican pupils in the secondary schools of New York City, what content would be useful, and what methods would be most effective in teaching pupils who are primarily concerned with learning to speak and read English.

The science project was developed under the advisorship of Professor Hubert Evans and other members of the Science Department of Teachers College, Columbia University, in conjunction with the Puerto Rican Study Staff and officials of the Board of Education, as well as the principals, supervisors, coordinators and teachers of the schools involved in the experiment.

Preliminary survey of twenty classes from twelve different junior high schools provided an over-all picture of teaching methods and instructional materials commonly used in the teaching of science in New York City junior high schools. It also provided the basis for selecting the most favorable and appropriate school as the locus for this project. With the approval of the Puerto Rican Study Planning Committee and other school authorities, Junior High School 118, Manhattan, was selected as the pilot school due to its accessibility, availability of cooperating teachers, and the high concentration of Puerto Rican pupils in the school.

Four experimental and two non-experimental seventh grade classes in the pilot school participated in the project. Three of the four experimental classes were all-Puerto Rican classes. The other was a mixed class in which fifty per cent of the pupils were Puerto Rican.

A science questionnaire based on experiences common to the cultural background of Puerto Rican children was developed and administered to the four seventh grade experimental classes. It was available in both English and Spanish and administered in the language of the pupil's preference. The questionnaire was intended to explore the past science experiences of the Puerto Rican pupils, their science interests, their attitudes toward learning science and the difficulties encountered in learning it.

The past experiences most frequently checked by the pupils of Puerto Rican background in the classes involved in the survey were experiences connected with country-life and agriculture: planting seeds and observing their growth, raising animals on the farm, in the home or laboratory, visiting a dairy farm, and harvesting a crop. This does not mean, however, that all the pupils studied came from the rural communities, but that somehow they had rural experiences either in school, in the home, or out in the country.

The Puerto Rican pupils showed definite interest in studying science. The four top-ranking interests were: experimenting with light and learning how we see, visiting a television studio, learning how to treat a wound, and hatching eggs in the science room.

The answers to the section of the science questionnaire dealing with the difficulties that Puerto Rican pupils, themselves, found in learning science were also most revealing. They showed that most of the pupils considered the subject matter too difficult; that they could not get the main ideas or did not know enough English to understand reading; that they did not know the purpose of the demonstrations nor what the demonstrations proved; and, that they forgot their readings very soon, and did not know how to use the science books.

Taking into account the information secured by the science questionnaire, the topics safety, health, and nutrition were selected as pilot areas for the study. The selection of these areas was also based on the result of personal interviews with the pupils and on the recognized importance of these areas in the adjustment of individuals to their environment.

At this point, it was thought advisable to identify the pupils' weaknesses and strengths in these areas. A series of tests were examined to determine their suitability for measuring the factual knowledge of the Puerto Rican pupils. The language level at which they were written made them unsuitable for this purpose. For this reason, a test in safety, health, and nutrition was developed at a simple level, but based on the scientific facts, principles, and attitudes suitable to the seventh grade level. (This was accomplished by selecting items concerning safety, health, and nutrition from the New York State Science Survey Test, 1955, and from the booklet *Teaching Tests to Accompany You and Your World* by Alfred D. Beck under the editorship of Paul F. Brandwein.)

The test was administered to pupils in the four experimental and the two non-experimental classes in February and again in June. It was available in both English and Spanish and administered in the language of the pupil's preference.

Resource units and sample lessons were then developed for the four experimental classes. Instructional materials for the pupils were developed at three different levels of understanding. They provided experiences which helped the Puerto Rican pupils develop scientific concepts, attitudes, and understandings which helped them in adjusting to their new environment. Spanish equivalents were given for the most difficult terms. Demonstration lessons and the specific suggestions which accompany the sample lessons helped the teachers in presenting these lessons. The sample lessons also served as prototypes for additional science lessons to be developed by the teacher. Evaluation exercises adapted to these pupils were also developed. These were characterized by the same attributes of the sample lessons. They were simple, pictorial, concise, and concrete.

The pupils of Puerto Rican background profited substantially from the specially prepared science materials. This profit showed in the work done by the experimental classes, in the exhibits prepared for the science fair, and in the comparison of gains in science knowledge with classes which did not use the special materials, but followed the general school emphasis on safety, health, and nutrition. (The four experimental classes showed an average gain of 12.2 points while the non-experimental classes showed a gain of only 1.3 points.)

During the school year 1955–56, the experiment was extended to three other junior high schools besides 118–M, namely, 101–M, 65–M and 52–X. Teacher's and pupils' materials were provided for sixteen different classes which tried out the materials. With the cooperation of teachers, coordinators and supervisors, a better evaluation of the program was possible.

The demand on the part of the teachers for more materials like the ones tried out in the experiment and the request from non-science teachers for more specific instructions for teaching science to the Puerto Rican pupils gave birth to two companion volumes, a *Guide to the Teaching of*

Science to the Puerto Rican Pupils in the Junior High Schools of New York City and a set of fourteen *Sample Lessons* with specific instructions to carry out the lessons.

The Guide is not intended to be a course of study but rather a supplement to the New York City science syllabus. It describes some methods and procedures, experiments and materials which have proved to be successful in teaching science to the Puerto Rican pupils at the junior high school level. The Sample Lessons are to be used in conjunction with the resource units on safety, health, and nutrition which appear in the Guide. They do not cover all the topics suggested in the units, but serve as models which teachers can follow in developing other lessons.

During the current year these two volumes are being used in thirty-five different classes among eleven junior high schools in New York City. These two volumes are now in the process of revision and the Board of Education has authorized the Puerto Rican Study to put them in printed form for distribution to all New York City junior high schools confronted with teaching Puerto Rican pupils.

It is hoped that this effort in improving science teaching will open new avenues of study for teaching not only science but other areas of the curriculum as well. May it encourage teachers to do a little research of their own towards developing ways and techniques adapted to meet the needs of not only the Puerto Rican pupils, but all pupils in our schools.

THE PREDICTION OF ACHIEVEMENT IN JUNIOR HIGH SCHOOL GENERAL SCIENCE *

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PURPOSE

THE problem of this investigation was to determine the significance of the variables of sex, grade placement, arithmetic development status, and individual order of rank according to final general science scores, both separately and in all possible interacting combinations, for purposes of estimation and predication of achievement in junior-high school general science.

METHODOLOGY

The fifty-four subjects for this investigation, eighteen from each grade, were randomly chosen from approximately five hundred pupils of grades seven, eight, and nine of five New York City junior high schools. The randomization was continued until the cellular structure of the experimental design was completed.

Arithmetic development status, mental age, and initial and final general science scores were measured by standardized tests. The initial general science test was administered in September while the final general science test was given the following June. Mental ages and initial general science scores were used as concomitant variations to give greater precision to the experiment.

The basic pattern for this investigation was that of factorial design with the application of the analysis of variance. Specifically, the experimental design utilized a two-by-three-by-three-by-three arrangement of the factors involved, i.e., two sexes,

* A paper presented at a meeting of the National Association for Research in Science Teaching, Atlantic City, New Jersey.

three arithmetic development stati, three grades, and three individual rank orders. The design was further refined by the use of the analysis of covariance for the control of the two concomitant variations, mental ages, and initial general science scores.

Orthogonal polynomials were used to derive the regression equations for estimation and prediction of achievement in general science.

FINDINGS

The findings of the investigation are as follows:

1. When no allowance was made for the effect of initial general science scores and mental ages upon final general science scores, — sex, arithmetic development status, and individual rank order were found to be significant, while the interactions of sex × arithmetic development status was doubtful.

2. With the elimination of the effect of initial general science scores upon final general science scores, the interactions sex × grade placement, sex × arithmetic development status, sex × individual rank order, arithmetic development status × grade, individual rank order × grade, and arithmetic development status × individual rank order were significant. In addition, the three single variables of sex, grade, and individual rank order were significant while arithmetic development status were doubtful.

3. When the effects of both initial general science scores and mental ages were eliminated, none of the interactions were significant while all of the single variables, sex, grade placement, individual rank order, and arithmetic development status were significant.

4. All of the orthogonal components of the regression equations for the estimation of observed and predicted final general science scores from sex, grade placement, arithmetic development status, and individual rank order were significant.

CONCLUSIONS

On the basis of the nature of the findings, the following conclusions were drawn:

1. The utilization of factorial design with the analysis of variance and co-variance resulted in increased precision of the experimental comparisons through the control of two sources of variation, initial general science scores and mental ages.

2. Achievement in general science in the New York City junior high schools is not significantly affected by any interacting combination of sex, arithmetic development status, grade placement, and individual rank order when the effects of initial general science scores and mental ages have been partialled out.

3. The variables of sex, arithmetic development status, grade placement, and individual rank order are singly significant, and hence, are potential predicators of achievement in New York City junior high school general science after the effects of initial general science scores and mental ages have been eliminated.

4. The regression equations derived can be effectively employed for predication of success in junior high school subjects to the restrictions imposed upon this study for their derivation.

IMPLICATIONS

The results of this study indicate possibilities of greater economy and efficiency in the guidance and teaching of junior high students in general science. Increased number of studies in this area can undoubtedly augment and refine the educational advantages accruing from prediction instruments. The fact that the results varied at different stages of the study points to the necessity for cautious selection and utilization of experimental procedures with adequate safeguards against uncontrolled sources of variation.

"FOR THE RECORD" FOLLOW-UP

CLARENCE M. PRUITT

SKIP reading this article if you did not read the preceding "For the Record" article in the April 1960 issue of *Science Education*. In that article the writer stated certain facts and made certain observations. While we did not expect much if any refutation of the *facts* stated, we did expect some comment regarding a number of our assumptions.

To our surprise, and to our disappointment, too, very few persons have sent any comments to the writer. The paucity of comments might be interpreted in a number of ways.

One of the most obvious interpretations would be that very few persons read the article. If true, that in itself, would be a great disappointment. A second interpretation is that most NARST members do not care one way or the other in regard to a number of questions raised in the article. A third interpretation is that readers do not support the writer's assumptions but graciously refrained from writing because they did not desire to hurt the writer's feelings. We are very sorry if this is true because that belief is in error.

On the other hand, the paucity of reactions might well be interpreted to mean approval of a number of beliefs mentioned in the article approved by certain NARST members but questioned by the writer.

1. The belief of many members that future membership in the organization should continue to be quite exclusive, with probably the completion of a doctoral study being a prerequisite to membership.

2. Many members seemingly agree with certain minority members that a relatively few of the considerable number of members are potentially suitable officer material! Or it may be that few members have any ambition or desire for taking on the strenuous responsibilities of an officer!

3. More aggressive leadership on the part of the secretary-treasurer would seem to be highly desired by many members.

4. The trend toward centralization of educational organizations in Washington.

Seemingly very few members are very much concerned as to whether NARST becomes owner of *Science Education* when we lay aside our Editorial responsibilities. Not one person indicated any interest in or desire for such future transfer. Evidently most members do not care one way or the other. The only members in the past manifesting any such desires are the few who would like to take over *Science Education* as of now. And lastly, no member wrote to us denying the observation that most members felt they could do a better job as Editor than the present one!

A REPORT ON THE RELATIONSHIPS OF THE NARST WITH THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE FOR THE YEAR 1959–60 *

GEORGE GREISEN MALLINSON

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INTRODUCTION

As with previous years, the report of your representative will deal with the three facets of the activities and relationships between the NARST and AAAS. These areas are (1) representation at the meetings of the Cooperative Committee on the Teaching of Science and Mathematics of the AAAS, (2) participation of your representative at the meetings of the AAAS Council at the annual convention of the AAAS in Chicago, Illinois, December 27 and 30, 1959, and (3) presentation of a Research Symposium at the One Hundred Twenty-Sixth Meeting of the AAAS in Chicago, Illinois, on Monday, December 28, 1959.

ACTIVITIES WITH THE COOPERATIVE COMMITTEE ON THE TEACHING OF SCIENCE AND MATHEMATICS OF THE AAAS

Meetings of the Cooperative Committee

The Cooperative Committee of the AAAS met twice during 1959. The first meeting was held in the AAAS Building in Washington, D. C. on March 20 and 21, 1959. The second was also held at the same place on October 23 and 24, 1959.

The costs of attendance of your representative were borne by sources other than the treasury of the NARST.

* A report made by the NARST Representative on the Cooperative Committee on the Teaching of Science and Mathematics of the AAAS at the Thirty-Third Annual Convention of the National Association for Research in Science Teaching at the Hotel Sherman, Chicago, Illinois, February 12, 1960.

Membership and Attendance at the Meetings of the Cooperative Committee

Those in attendance at the second meeting in Washington and the societies they represent are listed below:

Members Present

J. W. Buchta, American Institute of Physics, Chairman
C. L. Agre, American Chemical Society
John W. Cell, American Society for Engineering Education
Phillip S. Jones, Mathematical Association of America
Robert T. Lagemann, National Science Teachers Association
George G. Mallinson, National Association for Research in Science Teaching
John R. Mayor, Director of Education, American Association for the Advancement of Science
Bruce E. Meserve, National Council of Teachers of Mathematics
Brother G. Nicholas, National Association of Biology Teachers
Fred H. Norris, Botanical Society of America
Leonard O. Olsen, American Association of Physics Teachers
Thornton L. Page, American Astronomical Society
W. E. Restemeyer, Engineers Joint Council
Wayne Taylor, American Association for the Advancement of Science Academy Conference, Vice-Chairman
Bernard B. Watson, Secretary
Richard L. Weaver, American Nature Study Society
Harold E. Wise, Section Q (Education) American Association for the Advancement of Science
Theodore Woodward, American Geological Institute

Present by Invitation

William Morrell, National Science Foundation
Dael Wolfle, Executive Officer, American Association for the Advancement of Science

Robert T. Lagemann was introduced as the representative of the National Science Teachers Association, succeeding Robert

Stollberg. Announcement was made of the appointment of Harry F. Lewis as the representative of the Division of Chemical Education, American Chemical Society succeeding Fred B. Dutton.

Activities and Deliberations of the Cooperative Committee

The activities and deliberations of the Cooperative Committee are too vast to enumerate here. The minutes of the meetings in which they are reported were distributed to the membership of the NARST at the convention where this report was made. Therefore, your representative has taken the liberty of reporting those activities and deliberations that seem most important.

Report on the Subcommittee on Teacher Certification:

The report of the subcommittee on Teacher Education, now referred to commonly as the Garrett report, appeared in *School Science and Mathematics,* the journal of which your representative is editor. There was some discussion concerning the extent to which the report had been endorsed officially by the entire Cooperative Committee. The AAAS Board had not endorsed the report because there had been insufficient time to study it. The Cooperative Committee however took two actions with respect to the published report, namely these:

1. The Committee voted that the minutes of the November 1958 meeting pertinent to the report be interpreted to mean that the Cooperative Committee had approved the report in principle.

2. The Committee voted to order 5,000 reprints in a 12-page format so that the first page might be used as a title page and the second page for an explanatory paragraph indicating the status of the report that was sent out. The explanatory paragraph read as follows:

"The Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science, through its subcommittee on the Certification of Science and Mathematics Teachers, presents this report to the societies represented on the Committee and to others interested. The Committee has endorsed the report in principle and is now distributing it in order to promote discussion and action. Individuals and organizations desiring to endorse the report or to suggest modifications should write to Dr. Bernard B. Watson, Secretary, AAAS Cooperative Committee, Operations Research Office, The Johns Hopkins University, 6935 Arlington Road, Bethesda 14, Maryland. In order to have the comments considered by the Cooperative Committee, they should be received by Dr. Watson no later than October 1, 1959."

It was then agreed that each member of the Cooperative Committee assume the individual responsibility for bringing the report to the attention of the organization he represents. This was done. Also, the AAAS took the responsibility of making it available for the participants at the TEPS conference that was held at the University of Kansas on June 24–28, 1959, as well as to other groups and organizations not represented on the Cooperative Committee.

A number of comments were returned. In general, your representative agreed with the report, since it took the total view of training science teachers. However, a number of organizations concerned with specialized areas of science offered specific criticisms of specific sections. In general, those groups were concerned with more subject-matter training in specific areas. Practically, however, a science teacher must be trained in several areas. Thus, the report seemed to your representative to be a reasonable compromise of all the issues.

However, there was major dissent with the report by the American Association of Physics Teachers and the American Institute of Physics. A number of the elements of dissent involved minor factors not worthy of mention here. However, one section of the comment of the groups represented a major conflict with the thinking of the NARST. The specific dissent in the pamphlet containing the comments of the AAPT and AIP about the report reads as follows:

"IV. *The high school 'Physical Science' course:*

"Very few of the high school 'Physical Science'

courses presently taught are interesting and valuable to the students. It is a difficult course to teach well. The academic background required of a competent teacher is both difficult to specify and secure. We are of the opinion that special terminal introductory courses in physics and chemistry would be better and would certainly be more effectively taught. *We, therefore, recommend that this report not support a 'Physical Science' course and perhaps the report should even include a paragraph explaining the reason.*"

Your representative did not choose to "take it lying down." He therefore prepared the following rebuttal, and distributed it to the membership of the Cooperative Committee as well as to many other persons and groups that might be interested. The rebuttal follows:

September 1, 1959

To: Members of the Cooperative Committee on the Teaching of Science and Mathematics of the AAAS

From: George G. Mallinson, Representative of the National Association for Research in Science Teaching on the Cooperative Committee

Re: Revisions suggested by the American Association of Physics Teachers and American Institute of Physics in Recommendations for the Preparation of High School Teachers of Science and Mathematics—1959 (Garrett Report)

Dear Colleagues:

I read with a great deal of interest the revisions suggested by the Associations mentioned above. In general, I agree that most of them are worthy of positive consideration except one, namely, the one that appears on the top of page 5 of the suggested revisions. It reads as follows:

"IV. *The high school 'Physical Science' course:*

"Very few of the high school 'Physical Science' courses presently taught are interesting and valuable to the students. It is a difficult course to teach well. The academic background required of a competent teacher is both difficult to specify and secure. We are of the opinion that special terminal introductory courses in physics and chemistry would be better and would certainly be more effectively taught. *We, therefore, recommend that this report not support a 'Physical Science' course and perhaps the report should even include a paragraph explaining the reason.*"

I was somewhat surprised at the recommendation since it seems completely inconsistent with the logic we expected of physicists, and also with the purpose of the Garrett report. I shall attempt to explain my views:

1. On what evidence is the first sentence based? Why very few? Who made the analysis and when?
2. With respect to the second sentence, is not general science equally, or even more, difficult to teach? Also is the training for a teacher of physical science more difficult to specify and secure than that of a general science teacher or of a teacher who teaches both chemistry and physics? (There are incidentally vast numbers of the latter in the United States.)

   If the logic of the recommendation is followed, general science should also be abolished, and teachers who teach both chemistry and physics should be disavowed.
3. I note that it is an *opinion* expressed about "special terminal introductory courses in physics and chemistry." Where are the facts? What would the courses be like? Would they be more effectively taught? They have been attempted on numerous occasions before (this can be documented). The fact that they are almost impossible to find is ample evidence of the esteem with which they were held, and the effectiveness with which they were taught, despite opinions to the contrary.
4. The logic for the abolition of physical science is similar to the specious logic expressed in an article published several years ago. This article suggested the abolition of physics and its replacement with physical science for reasons startlingly similar to those given here. The citation for the article is as follows:

   Hurd, Paul DeH., "The Case Against High School Physics." *School Science and Mathematics,* LIII (June 1953), 439–49.

   I might point out that the only rebuttal to this article I have ever seen is cited below:

   Mallinson, George G., "The Role of Physics in the Emerging High School Curriculum." *School Science and Mathematics,* LV (March 1955), 211–16.

   The author of the rebuttal pointed out that Hurd had attempted to "bury the wrong body." However, we here have the spectacle of the alleged corpse becoming the grave digger.

Frankly, there are several facts that must be considered. While general physical science is still young, it is healthy, thriving, and growing. *There are more students now electing this course than are electing physics.* The numbers are difficult to establish since the course is taught under several different names (i.e., advanced general science, senior science, general physical science, etc.).

Within the past year, four new books appeared in this area, one of which received an award from the Graphic Arts Institute for its general quality.

At least two more are scheduled for publication next year.

In the final analysis, the function of the "Garrett Committee" was not to recommend curricula or abolish courses. Its function was to ascertain what is now taught in science and to recommend programs for training teachers to do the job properly.

One may point out that the committees subsidized by the NSF to revise physics, chemistry, and biology are ample evidence that all sciences need improvement. None is being taught optimally nor are well-trained teachers available. Obviously, this is not a reason for abolishing all of them.

It would seem, therefore, recognizing that numerous groups have recommended physical science (including the President's Commission and the Conant Report), that since the course is thriving even more than physics in terms of numbers, and newer and better materials are constantly being produced, the task is to do the job well, not to abolish a course or refuse to suggest a program for training teachers to teach it well.

Respectfully,
(Signed)
GEORGE G. MALLINSON,
NARST Representative

As one might expect, the issue was raised at the meeting on October 23 and 24, 1959. The ensuing "discussion" was heated. Suffice to say, the Cooperative Committee did not support the recommendations made by the AAPT and AIP for physical science.

It was agreed that the final report would be published in *Science*.

Extension of the Science Teaching Improvement Plan:

The grant for the original STIP program has "expired." However under a new grant from the Carnegie Corporation, there are provisions for two experimental studies. The first study concerns the use of special teachers in grades 5 and 6 for science and mathematics. Your representative served as a consultant at the summer meeting in 1959 in Ann Arbor for developing the study. The cities in which the experiment is being carried on are Versailles, Kentucky; Cedar Rapids, Iowa; Washington, D. C.; and Lansing, Michigan. Information about the progress of the experiment should be available for the next meeting of the NARST.

The second study dealt with experimentation in the education of science teachers, particularly with reference to professional education requirements. The study is called the Study in Teacher Education Project. In effect, small grants for research are awarded by STIP for proposals from colleges and universities that are approved under the conditions established for the study.

In addition the AAAS was notified of a grant from the Carnegie Corporation of New York for a study of Teacher Certification in Science and Mathematics by the National Association of State Directors of Teacher Education and Certification (NASDTEC). The purposes of the study are outlined in *Science*. CXXX (November 6, 1959), 1237–8.

The study is designed to provide a basis for national standards for certification of teachers of science and mathematics. The Director is Dr. John R. Mayor and the Associate Director is Dr. William Viall, Chief Certification Officer of New York State, who will work in the Washington office of the project for 18 months. A major report will be disseminated at the end of the study.

Other Activities:

Three other activities seem worthy of note here:

1. There has been considerable discussion by the Cooperative Committee over the past few years about licensing science teachers on a national basis, and also finding means of designating or honoring "expert" science teachers. The various problems involved in such undertakings have been discussed extensively. The entire Committee will attempt to seek information that may shed light on the subject. No specific action was taken at either meeting.

2. Another concern has been the possibility of establishing model high schools in which the total program might reflect the best thinking with respect to the secondary

education. The matter was discussed by Dr. John R. Mayor with Dr. T. M. Stinnett of the National Commission on Teacher Education and Professional Standards. In general, the views of Dr. Stinnett were that: (a) state departments of education should be involved in the selection of model schools in their states and in the development of the model programs, (b) model high schools should not be schools for gifted students but should be comprehensive high schools, and (c) university high schools might be used as model schools.

No action was taken in connection with the proposal for a program of model high schools, but the subcommittee was asked to meet following the adjournment of the full Committee and to report at the next meeting.

3. Interest was expressed at both meetings concerning the need for examining elementary science more closely. It was agreed that the members of the Committee should bring to the next meeting suggestions for improving elementary science curricula and the programs for science training for elementary teachers. It was also agreed that some consideration should be given the possibility of seeking funds for an objective study of elementary science.

DELIBERATIONS OF THE AAAS COUNCIL

The AAAS Council met at 4:00 P.M. Sunday, December 27, 1959 and 9:00 A.M. Wednesday, December 30, 1959 in the Morrison Hotel in Chicago. A number of items of general business were conducted as well as some specific items with which your representative believes the NARST is specifically concerned.

The AAAS has taken steps to provide broader participation of its affiliated societies by establishing a number of study committees involving the Council members. The report of the Committee on Council Activities and Organization contained the following recommendation.

"The Committee on Council Agenda and Resolutions recommends the acceptance of the report of the Committee on Council Activities and Organization. It endorses the creation of the proposed standing committees and emphasizes the need of a Committee on Council Activities and Organization. It generally approves the proposed rules of procedure including the creation of special and advisory committees but recommends that these be initiated this year by the Committee on Council Activities and Organization only as the need arises and as personnel become available.

"It approves the recommendations contained in Part IV of the report."

Extensive discussion followed the presentation of the report. In general, the Council favored those aspects of the report that were designed to increase Council activity and to improve communication among the Council, the Board, the members and the affiliated societies of the AAAS. The problem that seemed to arise was the achievement of the objectives of the report without diluting or producing conflict in the administrative and legal machinery for managing AAAS affairs.

It was finally agreed that the objectives of the report be approved and discrepancies in the report be cleared up during the year by the Committee on Council Activities and Organization.

The Council also approved the following resolution concerning the elimination of the affidavit required by Section 1001(f) of the National Defense Education Act.

"WHEREAS, The general objective of the National Defense Education Act is the security and welfare of the nation and the strengthening of both through support of higher education; and

"WHEREAS, The requirement of the so-called disclaimer affidavit of this act:

"(a) discriminates against students receiving federal loans by requiring each to make an affidavit which is not required of other recipients of federal loans or of other beneficiaries of federal funds,

"(b) may be indefinite and uncertain in its legal application since the signer does not know which organization may be legally classed as subversive,

"(c) is not generally effective in discovering disloyalty and in promoting loyalty,

"*Therefore,* The Council of the American Association for the Advancement of Science believes that the national welfare, education and science, will be furthered by the deletion of the affidavit requirement from Section 1001(f) of the National Defense Education Act."

Your representative has conflicting views

with respect to the affidavit. He is of the opinion that anyone seeking such loans should be willing to profess loyalty. He is also aware that the signing of the affidavit certainly does not assure such loyalty. However, the affidavit has become an issue totally out of proportion to its importance and no doubt many persons have accepted the battle as a matter of principle purely for the sake of principle. There are other matters far more important that demand attention.

THE NARST RESEARCH SYMPOSIUM

The annual NARST Research Symposium was presented in Chicago to an audience of less than 50. This was considerably smaller than in previous years. The many concurrent meetings of interest to science teachers may have been responsible for the low attendance.

The program was as follows:

9:00 A.M.; George Bernard Shaw Room; Research Symposium. Arranged by Vaden W. Miles, Wayne State University and John C. Mayfield, University of Chicago

VADEN W. MILES, President, NARST, Presiding

1. Review of Research in Elementary Science Education. Betty Lockwood Wheeler, Central Michigan University, Mt. Pleasant, Mich.
2. Implications of the Findings of Recent Research in Elementary Science Education. Paul E. Blackwood, U. S. Office of Education, Washington, D. C. (Read by Helen J. Challand, National College of Education, Evanston, Ill.
3. Review of Recent Research in Secondary Science Education. Hubert Evans, Teachers College, Columbia University.
4. Implications of the Findings of Recent Research in Secondary Science Education. William B. Reiner, Bureau of Educational Research, Board of Education, City of New York, Brooklyn, N. Y. (Paper read by Edward Victor, Northwestern University.)
5. Review of Recent Research in College Level Science Education. John H. Woodburn, Johns Hopkins University.
6. Implications of the Findings of Recent Research in College Level Science Education. Herman R. Branson, Howard University.
7. Summary. Cyrus W. Barnes, New York University.

As usual, the papers from the Symposium will be published in *School Science and Mathematics* (Note: They appear in *School Science and Mathematics,* XL (May 1960), 351–99.)

CONCLUSION

Your representative, as in previous years, heartily endorses the relationship with the AAAS. They provide a "sounding board" for the objectives of the NARST and also enable the NARST to remain abreast of national efforts to improve science and mathematics education.

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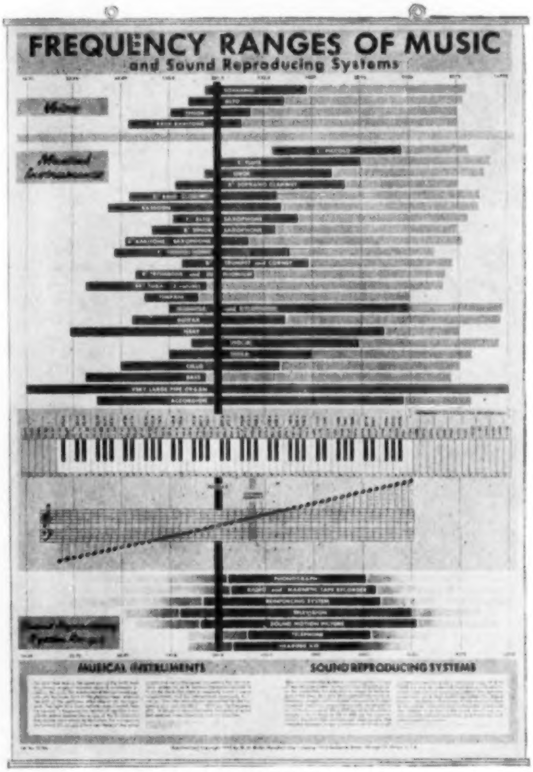
(Continued from inside front cover)

A New Welch Wall Chart



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